# AIRCRAFT & MISSILES

Chilton Publication APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES September 1960

## One Pound of Satellite—How Much Is It Worth?... 28

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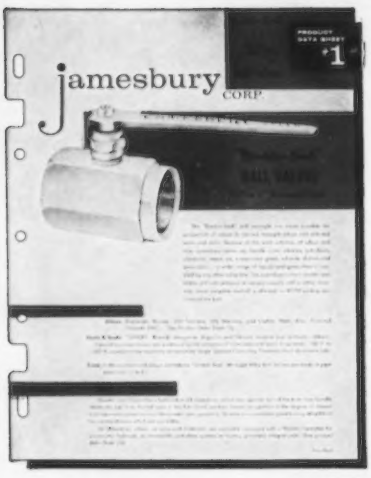
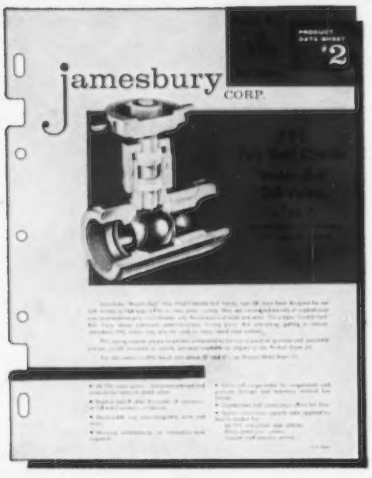
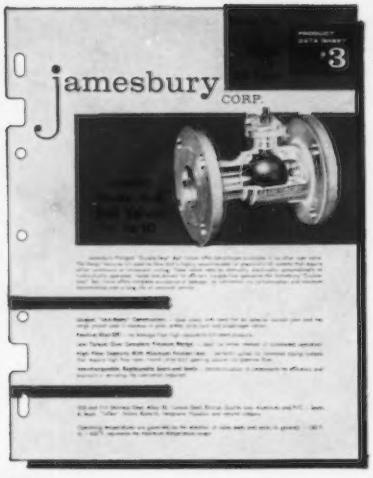
# Yours For The Asking!

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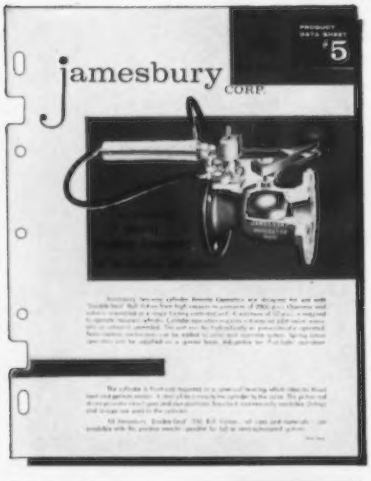


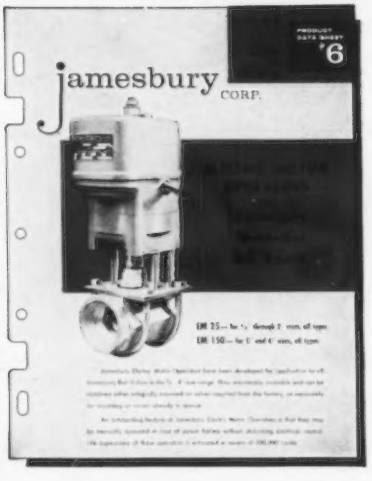


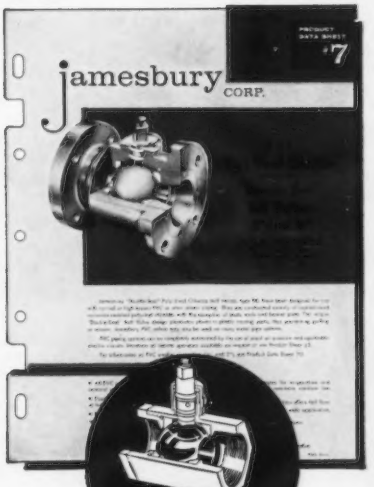


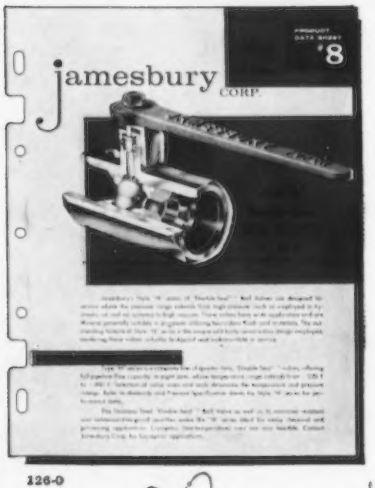


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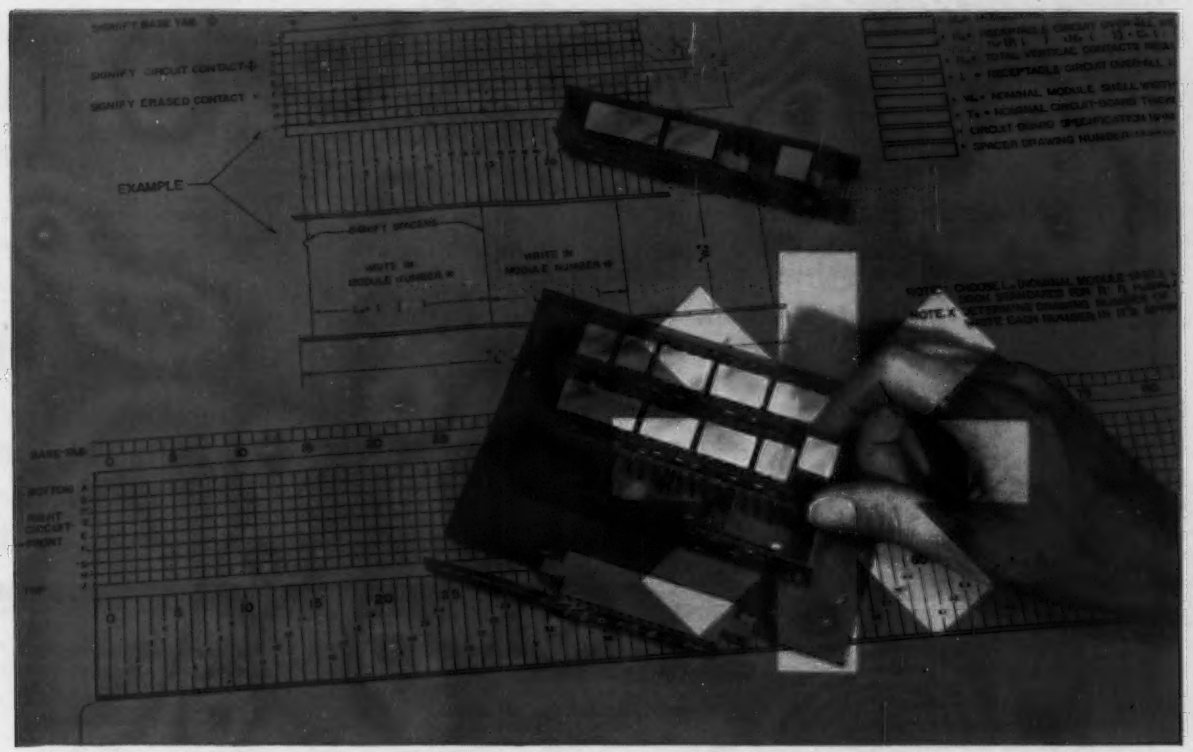


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September, 1960 *Volume 3, Number 9*

# AIRCRAFT & MISSILES

APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES

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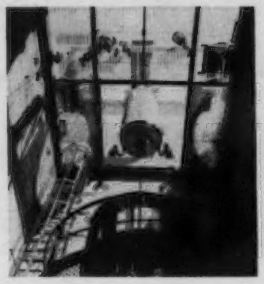
## THE COVER STORY

Latest of the ICBM breed is Minuteman, a solid-propellant, three-stage, steel bird. Minuteman's first stage is born at Thiokol-Utah where motor cases of Ladish D6-AC are filled with polybutadiene acrylic acid, and cured in underground pits. "Incubation" period can be controlled by varying amount of heat in the "nest." See page 17.



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*NEW DEPARTMENT . . . EDITED FOR MANAGEMENT. Look for it on page 13. A capsule of the month's business developments and trends is at your fingertips. Data is a part of the research done under Chilton's Marketing Assistance Program, M-A-P.*

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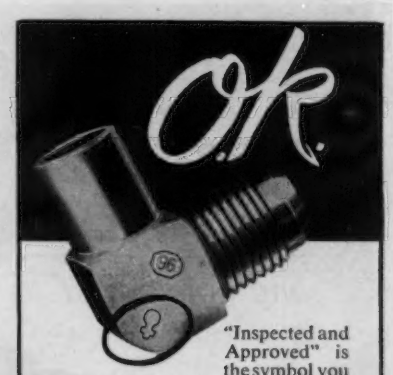


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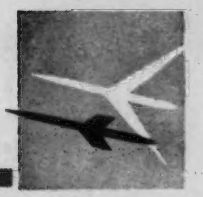
EDITORIAL



# Now It's Your Turn for Greatness

Two months of soul-searching days lie ahead. Then, on the eighth day of November, we shall be called upon to make a choice—a choice that will effect our destiny and ultimately that of the world.

Everyone must turn aside personal prejudices and petty grievances. Man, prone to human error, must make no error.

Four men have been placed before us for the two highest offices this country offers. The choice of men is ours. These men will make statements and counter-statements. Let us pray that facts are not bloodied in a war of words. Some promises have been made. Bigger and better ones are bound to come. Will they be kept? Should all of them be kept? Many such questions will rest heavily in the minds of men.

Each word, spoken and written, during the political battle, should be weighed carefully. No item should be considered too small to gloss over. This is more than an issue between rival parties. This is your issue. You are the judge, jury, and the one who will bear the verdict.

We are selecting men who must do more than bear sword in these crucial times. Our presidential team must be mighty with words, sincere and firm in their beliefs with a passion for freedom and a love for mankind. As though this were not enough, they must have personal dignity beyond the stature of any man; they must be highly capable of meeting attacks from within and without; they must possess that unique leadership quality of uniting all of us toward a common goal, regardless of our sociological and economic philosophies.

The heavy responsibility resting on the American public is awe inspiring.

Let's pledge ourselves not to shirk our duty. Let us vote and use the privilege with intelligence and wisdom.

In all humility, let's try by all the powers we possess to have that greatness which will make these United States truly great in the years ahead.

Tom MacNew

Editor

# Reader's Orbit

### Those Vicious, Vicious Practices

. . . Your June issue . . . outlines that reprints of various articles can be ordered . . . Please send two copies of the article appearing on pages 24 through 26 written by Mr. Scott of The Garrett Corporation. This article is of great interest to us and will complete our files documenting a study we have been making for some time in this connection.

Richard R. Brant
Contracts Administrator
Rosemont Engineering

. . . Several of us here in Contracts Administration have read Mr. Denham Scott's article entitled "Vicious Procurement Practices in DOD." His remarks are indeed most timely. We note that you offer reprints . . . and we would certainly appreciate receiving a half dozen for distribution to our own people. Please let us know if there is any charge for this service. Thank you very much.

David J. Schultz
Project Manager
North Electric Co.

*We have served up a phenomenal 350 reprints of this article to readers. The second print order is near depletion. In this issue look for "DOD Talks Back," an interesting rebuttal to Mr. Scott's stinging article.*

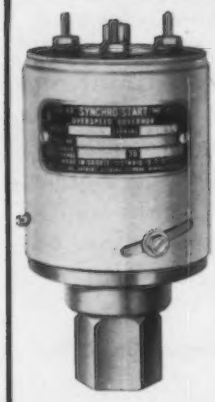
### Never, Never, Never

. . . We were amazed to read your special staff report on the Vickers VC 10 in the July issue, containing as it did some completely erroneous information on the Boeing 707. In discussing the advantages of stiff wing structure the statement is made that "a form of control reversal has been listed as a trait in the Boeing 707 in some slow-speed flight regimes. This condition has been suggested as a contributing cause in one accident."

Naturally this statement is of considerable interest to us at Boeing, and we wish to make it quite clear that the 707 has *never* experienced control reversal problems. I would suggest that your staff contact the company concerned before making such statements about its products.

Gordon S. Williams
Public Relations Manager
Transport Division
Boeing Airplane

*The Boeing 707-120 has experienced some unusual control responses during two engine flight, especially when the two engines not operating are on the same side. It is technically incorrect to refer to these responses as "control reversal." During the investigation of a 707-120 crash which occurred at Peconic River Airport, Calverton, Long Island, the maneuver which resulted from this unusual control response was discussed at length. It has been the subject of a great deal of study and in pilot training on the 707 is more properly called a yaw roll.*

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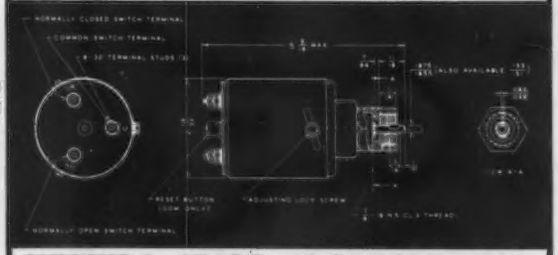

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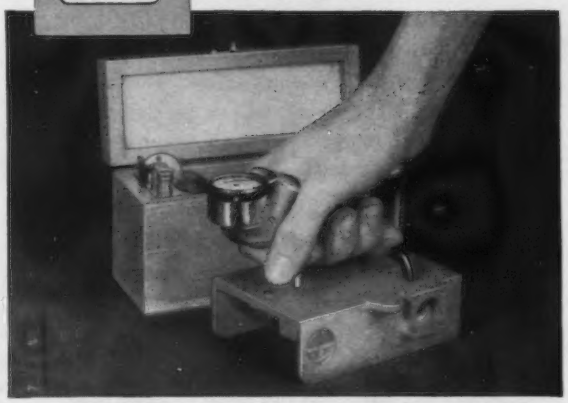

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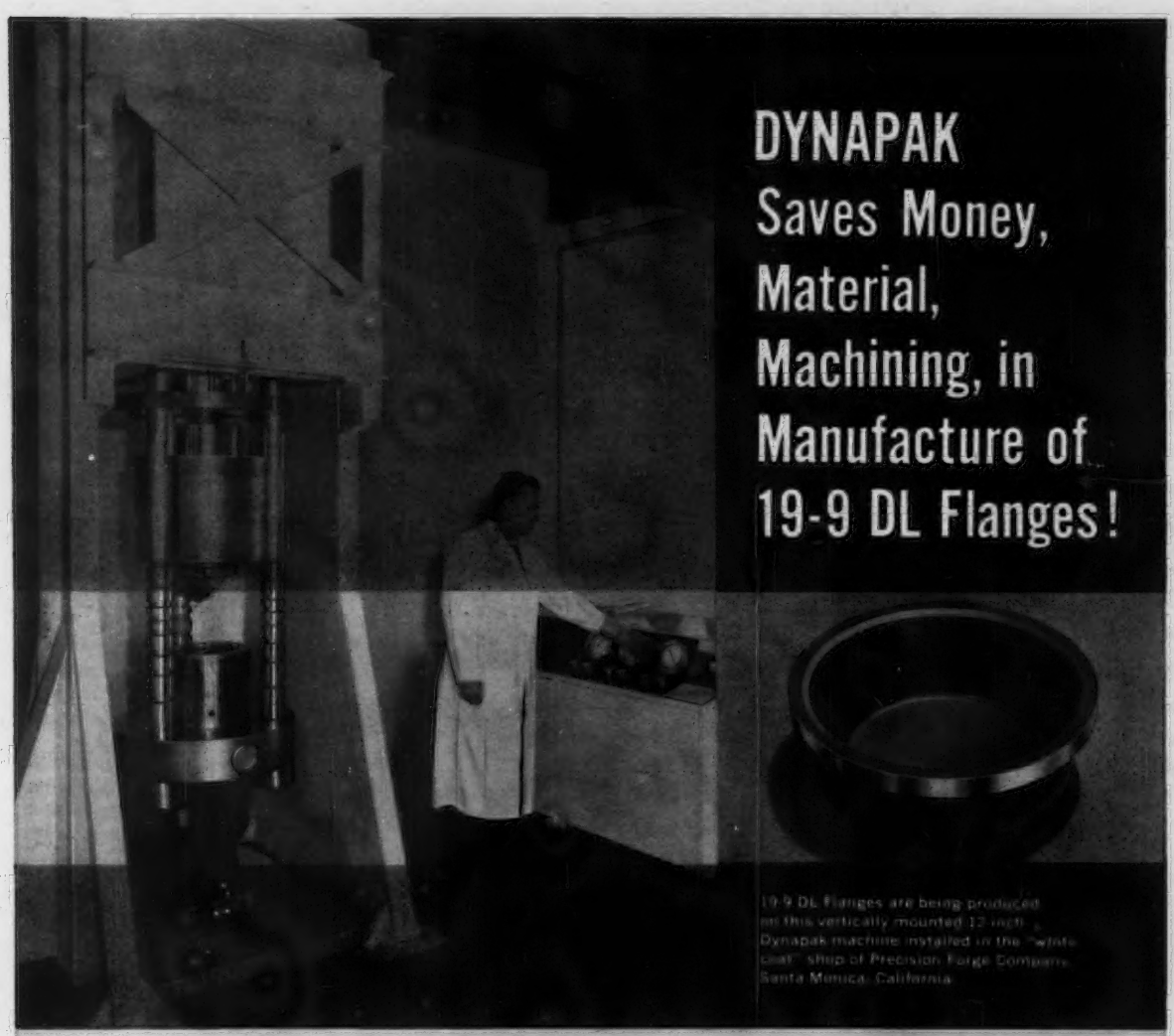

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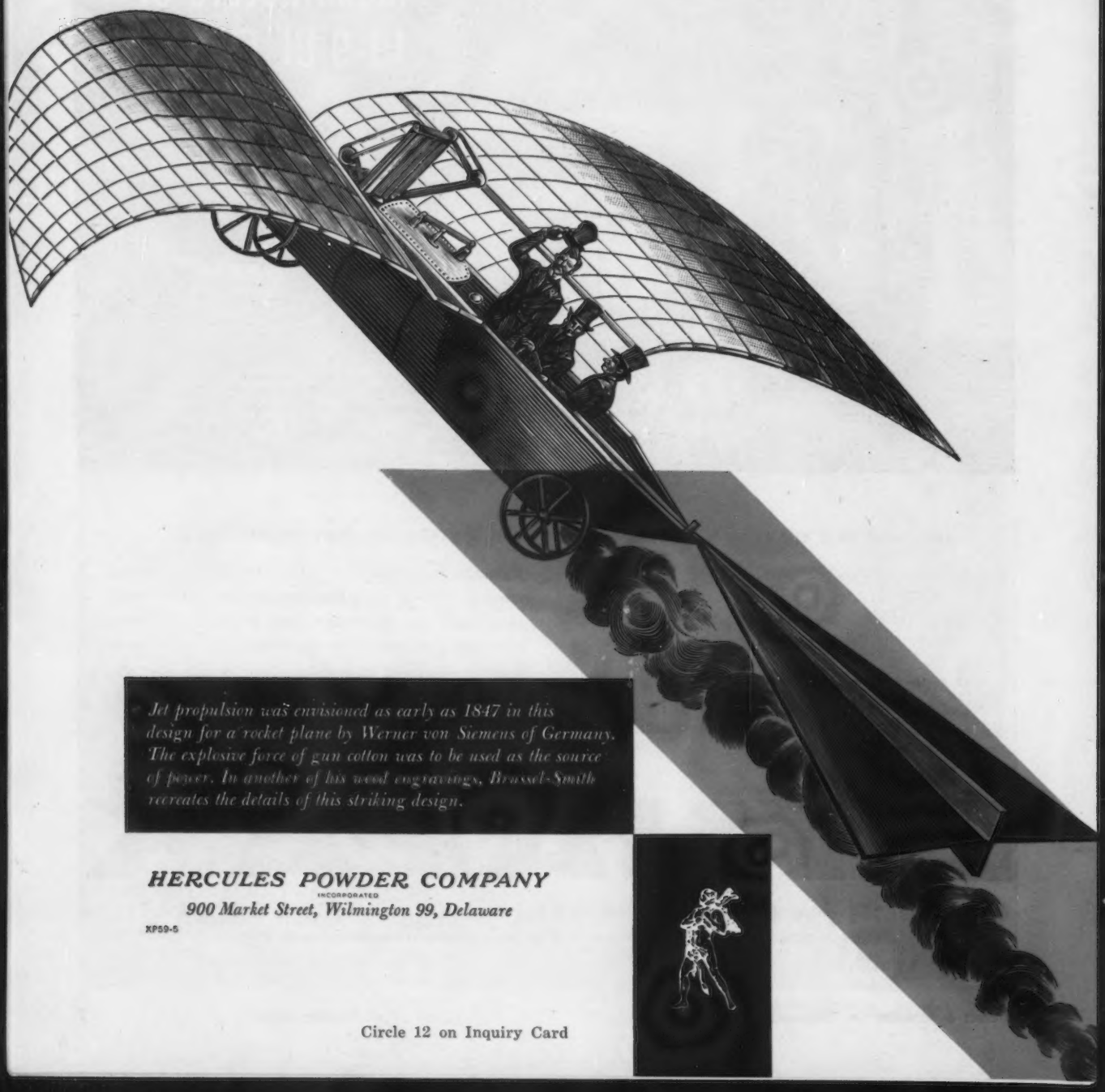

*Jet propulsion was envisioned as early as 1847 in this design for a rocket plane by Werner von Siemens of Germany. The explosive force of gun cotton was to be used as the source of power. In another of his wood engravings, Brassel-Smith recreates the details of this striking design.*

**HERCULES POWDER COMPANY**
INCORPORATED
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XP59-5

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## Your Datebook

**September 5-11**
1960 Farnborough Display
Society of British Aircraft Constructors
Farnborough, England

**September 6-16**
The Machine Tool Exposition—1960
National Machine Tool Builders' Asso.
International Amphitheatre, Chicago
(Production Engineering Show will run concurrently on Navy Pier)

**September 7-9**
Joint Automatic Control Conference
The American Society of Mechanical Engineers,
Instrument Society of America,
American Institute of Electrical Engineers,
American Institute of Chemical Engineers,
Institute of Radio Engineers
MIT, Cambridge, Mass.

**September 12-16**
Second International Congress
International Council of the Aeronautical Sciences
Zurich, Switzerland

**September 19-22**
National Symposium on Space Electronics and Telemetry
Institute of Radio Engineers
Shoreham Hotel, Washington, D. C.

**September 27-30**
Space Power Systems Conference
American Rocket Society, Air Force, Army, Navy, NASA, ARPA, AEC,
Miramar Hotel, Santa Monica, Calif.

**October 10-12**
National Electronics Conference
Hotel Sherman, Chicago, Ill.

**October 10-14**
National Aeronautic Meeting
Society of Automotive Engineers
Ambassador Hotel, Los Angeles

**October 17-21**
42nd National Metal Congress and Exposition
American Society for Metals
Trade and Convention Center. Phila.


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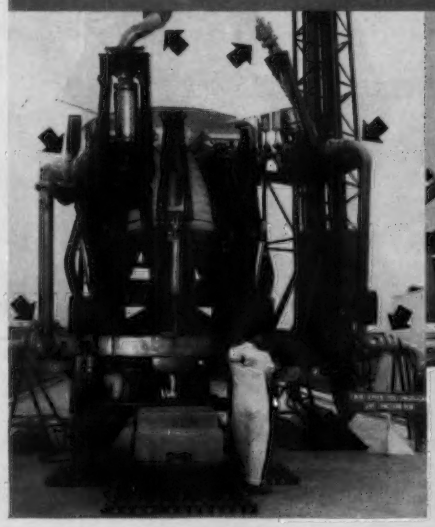
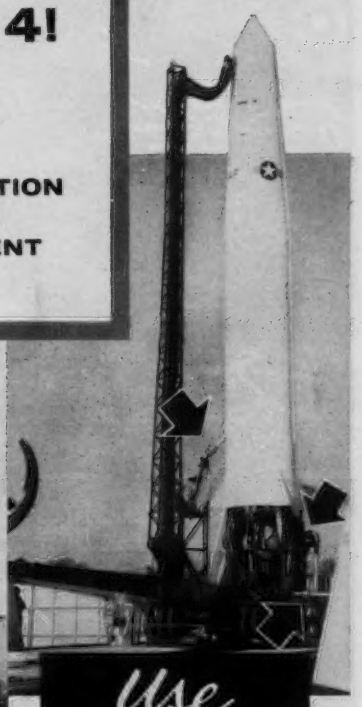
*Photos: Douglas-Air Force Thor IRBM.*





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SEND FOR LITERATURE
CATALOG 233A—"Flexible Ball Joints for Handling Liquid Oxygen and Missile Fuels."
CATALOG 269B—"Plane and Self-Aligning Swivel Joints for Hydraulic Service."

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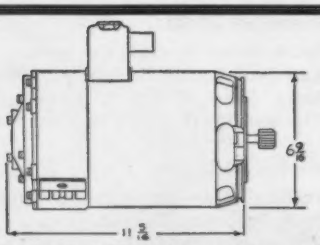
# BENDIX STARTER-GENERATOR PROVIDES "KICK" AND POWER FOR U. S. ARMY'S NEW "MOHAWK"

One of the largest aircraft ever to enter Army service, the Grumman AO-1 "Mohawk" has all-weather, day or night observation capabilities.

The "Mohawk's" electrical system includes two Bendix starter-generators and regulators. During engine starting, the units operate as high torque electric motors, with power supplied externally. As the engine ignites, the units automatically shift from starter to generator function.

These Bendix starter-generators are rated at 30V., 400 amps, with a speed range of 4,000-8,000 RPM, and meet MIL-G-6162. They are available with a variety of air spouts and have accommodations for QAD mounting.

This versatile package, combining starting and power generating functions, is another example of Bendix ability in delivering power requirements. Get further details from RED BANK GENERAL PRODUCTS DEPARTMENT.




*Bendix Red Bank 30837 starter-generator supplies 65 lb. ft. of starting torque at 1400 RPM. It is dependable, compact, and weighs only 53 lbs.*

GENERAL PRODUCTS DEPARTMENT

Red Bank Division

EATONTOWN, NEW JERSEY

THE Bendix CORPORATION

West Coast Office: 117 E. Providencia, Burbank, Calif.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.
Canadian Affiliate: Aviation Electric, Ltd., P. O. Box 6102, Montreal, Quebec

# Data Capsule

**SUMMARY OF MANAGEMENT TRENDS AND TECHNICAL DEVELOPMENTS IN THE AEROSPACE INDUSTRIES**

## MISSILES AND SPACE VEHICLES

### Design

MARK 6 re-entry vehicle will carry heaviest ICBM payload yet devised. It will be used with Titan II, and will be of ablating materials.

EXPERIMENTAL ENGINE at Rocketdyne eliminates separate gas generator. Main thrust is tapped to obtain hot gasses to drive the turbopump.

GAS GENERATOR driving turbopump system is eliminated in modified Rocketdyne MA-2 engine. Tests are part of experimental engine simplification program. Liquid-fuel turbopump uses solid propellant spinner to start, then switches to hot gases from thrust chamber. Aerojet General reports work on similar system.

RCA TRACKING SENSORS at opposite ends of balloon are major difference between first and second Project Echo experiments.

### Development

DOUGLAS AIRCRAFT now has full authority to develop the S-1V stage for Saturn. NASA contract authorizes firm to develop and build 10 S-1V's at its Santa Monica Div.

SECOND MERCURY SHOT at Canaveral may come this month. This will probably carry several items omitted from July's unsuccessful MA-1 (Mercury Atlas One) flight test. This test included over 200 lb. of instrumentation to monitor a severe mission abort--but it lacked environmental control system and stabilization jets.

CORVUS PROGRAM is being terminated. It was being developed for the Navy by Temco Electronics & Missiles Co. (Formerly Temco Aircraft.)

1500 MILE POLARIS is to be flight tested this year. 1200 mile motors are in quantity production at Aeroject General. Company is developing swivel nozzles for missile. The Navy meanwhile wants to start work on a 2500-mile-range Polaris.

PERSHING SECOND STAGE will soon be ignited in flight in tests at Canaveral.

MARTIN AND LOCKHEED will conduct separate six month "paper" studies for NASA on requirements of a nuclear rocket flight test program. First flight is planned for 1965.

ICBM SITE ACTIVATION is now under sole management of the Air Material Command. ARDC gets out of this area to concentrate on missile development.

LOW TEMPERATURE VALVES on Rocketdyne's Bravo 2 test stand weigh 6500 lbs. and can withstand 600 psi. They allow propellants to flow to the F-1 engine turbopump at the rate of three tons per second.

RADIATION EFFECTS on components for nuclear-propelled vehicles will be studied in a research facility to be set up at Convair-San Diego. Radiation source will be an improved three-million-volt electron/ion accelerator.

### Production

NEW CASTING TECHNIQUE reduces grain size of refractory metals, thus improving working characteristics. Method combines electron-beam processing and critical composition control. It was recently announced by Stauffer-Temescal Co.

IMPROVED FABRICATION METHODS are expected to allow large scale production of solar cells approaching 15 per cent efficiency.

EXPLOSIVE FORMING of end closures for Polaris solid propellant rocket chambers is now a production process at Aerojet-General's Chino Hills Lab.

### Procurement

NASA PROCUREMENT this decade will total between $12-billion and $15-billion, according to present plans.

ASTRONOMICAL OBSERVATORY PROGRAM soon starts new procurement concept: standardized satellites. Basic satellite system will be kept "in stock" instead of being custom-made for each experiment. Specs will cover basic structure, power supply, telemetry.

## AIRCRAFT

### Design

NUCLEAR AIRCRAFT design conceptions were released by the Air Force and Convair-Fort Worth after long delay. Drawings show swept-wing, canard-type planes with assembly of jet-like engines in tail. Vertical stabilizer-rudder assembly is at each wing tip. Horizontal stabilizer-elevator surfaces are placed far forward on fuselage.

NEW BUSINESS PLANE is planned by Cessna. Firm says it will represent "a basic new approach to twin-engine aircraft." Cessna hopes to have it on the commercial market in 1962.

BOUNDARY LAYER CONTROL RESEARCH at Northrop Corp. will explore three-dimensional effect of a large chord wing. Under new ARDC contract, Northrop will also study interference of fuselage wing and strut-wing.

FIAT 7002 HELICOPTER, now undergoing tethered tests outside Turin, Italy, uses a Fiat 4700 engine to supply compressed air jets at rotor tips. Fuel tanks are fitted to the roof just below the rotor and near its axis.

J85 FOR VTOL? General Electric says a dry (non-afterburning) J85 lift engine with 9-to-1 thrust-to-weight ratio can be assembled from current production hardware. It would reportedly deliver over 2700 lb thrust. In WADD tests, J85's were run in both vertical and horizontal positions and during transition.

G.E.'s J93 MACH 3 cruise engine for B-70 is based largely on J79. Engine includes variable stator compressor, single shaft, and converging-diverging exhaust nozzle. Materials in engine use include new high temp alloys. Honeycomb structure used in some areas.

### Development

RYAN VERTIPLANE is being rebuilt for NASA. Flight tests will resume at Moffett Field where the V/STOL craft made 21 successful flights before crashing last February.

J85-5 TURBOJET is now undergoing flight evaluation in an instrumented T-38 trainer.

LOW LEVEL APPROACH for B-52's is being developed at Boeing Wichita and SAC with special study of air turbulence effects below 1000 ft.

ESCAPE CAPSULE DEVELOPMENT at Chance Vought now has an electrical system for initiating escape. Greater reliability led to system being chosen over cartridge-actuated gas pressure and mild detonating fuse methods. It would eject entire cockpit.

EXPERIMENTAL UNDERWATER STORAGE TANKS recently installed by Firestone in Gulf of Mexico near St. Petersburg, Fla., are made of nylon-reinforced rubber. May be fore-runner of strategically located underwater fuel and supply dumps around the world.

### Production

CARAVELLE VII will be manufactured in the U. S. by Douglas. Production is slated to begin late in 1962. Plane's twin Avon engines are being replaced by CJ-805-23 aft-fans to increase range 40 per cent.

PICCHIO, a four place personal and liaison aircraft, is slated for large-scale production next year at Procaer's Milan plant.

FIRST B-52H is due to roll from the assembly line at Boeing-Wichita this fall.

269A HELICOPTER production line is being set up at the Culver City plant of Hughes Tool Co.

LYCOMING has received the first production contract for the 2200 shp T55-L-5 which will power the Chinook.

### Procurement

OVER $600-MILLION is slated to be spent on total of 120 Missileer planes in the next few years.

# The Aerospace MAP

## The Budget As A Barometer— Rising, Rising, Rising

Look for a boost in aerospace spending this fall as a result of congressional action on the defense budget. New obligational authority is $40,326,108, or $677,-108,000 over the President's request. Practically all of the boost provided by Congress is directed to aerospace.

Navy received an increase of $309,392,000 over the President's request, Army $22,985,000, Air Force $160,756,000. DOD funds were cut $16,025,000.

Navy money will go primarily to Polaris submarines; Air Force money to B-70 (45 will be built by 1966 under present plans), F-106 interceptors, an airborne alert, and the Samos satellite. Army money will go to general equipment modernization.

**Some Reluctance**—The administration has hinted at a reluctance to spend this extra money. It prefers to think that the original estimate was entirely adequate to provide for any and all defense needs. But, now that the money has been appropriated, pressures from the services, Congress, and aerospace interests are almost certain to jar some of the money loose from its tight fisted custodians.

If, by some remote chance, this does not happen, the new administration will find the defense till with some spare change. Both parties' candidates have pledged themselves to a bigger, better aerospace effort. The stand of the Democrats appears more positive. Since the extra funds were made available by a Democratic Congress, it seems unlikely this party would allow any funds to remain idle if they gained control of the executive branch.

**The Aerospace Market**—With the new increase, the aerospace market for fiscal 1961 is certain to top $14 billion. This is what the services have available in aerospace related areas. Increases or decreases are compared to the original Budget request.

| Air Force | Total | Change |
|---|---|---|
| Aircraft Procurement | $3,251,449,000 | +$275,449,000 |
| Missile Procurement | $2,615,120,000 | —$408,880,000 |
| Research, Development Test and Evaluation | $1,552,863,000 | +$218,863,000 |
| Airlift Modernization | $ 310,788,000 | +$310,788,000 |
| **Navy** | **Total** | **Change** |
| Aircraft and Missiles | $2,141,760,000 | +$ 28,760,000 |
| Ship Building and Conversion | $2,316,360,000 | +$284,360,000 |
| Research Development Test and Evaluation | $1,218,624,000 | +$ 49,624,000 |
| **Army** | **Total** | **Change** |
| Equipment & Missiles | $1,495,352,000 | +$158,352,000 |
| Research, Development Testing and Evaluation | $1,041,286,000 | $ 414,000 |

**Significance of Changes**—One of the most significant facts to note in the budget gymnastics is that Congress recognized a big hole in aircraft funding. A new budget category "airlift modernization" was created for Air Force. This drew about $310 million and was the top increase for a single category. Air Force drew an additional $275 million for aircraft procurement of other types. Navy's increase of $28 million for aircraft and missile procurement is too tangled to dig out individual gains.

The Military Air Transport System (MATS) has been long past due for an overhaul. Creating a new budget category for this could establish a trend that would see MATS take on a jet and VTOL capability.

**Overall Budget and Trends**—Though aircraft procurement is still high in total dollars, the bomber and interceptor are rapidly losing ground. The premature prediction of many that missile spending would outstrip aircraft in the late 50's will finally happen in the early 60's. But, manned space probes are predicted before the end of the fiscal year; and engineering advances in aircraft, with man in the system, will carry over into spacecraft development. Space exploration will be a $900 million business in fiscal 1961. But it will grow like Topsy. In five years it will triple to a $3 billion business. Aircraft spending will shrink from $6 billion to $3 billion in the same period.

There are no funds for B-58 Hustler procurement, beyond 1961. Boeing's B-52's are on order through 1962. Republic's F-105 and Convair's F-106 are the only "fighter" configurations in the Air Force funding plans. Navy will quietly stock up its aircraft carriers with McDonnell's F4H, NAA's A3J and Grumman's A2F and W2F for the lower, slower missions.

# The Aerospace MAP

## Business Moves

**Cessna Aircraft Co.** now has a marketing div. which will handle new commercial aircraft products under development.

**Bell Aerospace Corp.** is now operating as subsidiary of Textron Inc. Bell Aerospace is composed of Bell Aerosystems Co. (formerly Bell Aircraft's Niagara Frontier Div.); Bell Helicopter Co. (formerly Bell Helicopter Corp.); and Hydraulic Research and Manufacturing Co.

**Teldix** is new German firm established by The Bendix Corp. and Telefunken G.m.b.H. It will handle aircraft systems and equipment.

**Fluorocarbon Co.** moves to a new plant in Anaheim, Calif. this month.

**Adams-Rite Manufacturing Co.** recently acquired exclusive license to manufacture new self-locking control mechanisms.

**Hi-Shear Corp.** is new name of former Hi-Shear Rivet Tool Co., Torrance, Calif., fastener manufacturer.

**Avien Inc.** has officially acquired Electrol Inc., landing gear manufacturing firm.

**Industrial Technological Associates,** Cleveland, is developing a guide for the transportation and storage of all Navy missiles. Firm is tripling the area occupied by its engineering and technical staff.

## Facilities

**Aeronutronic,** div. of Ford Motor Co., is building a 120,000 sq ft building at Newport Beach, Calif. for its Tactical Weapon Systems Operations. This group is developing the Shillelagh missile.

**General Electric** starts construction this month in Waterford, N. Y. on $3-million plant for manufacturing basic silicone intermediate chemicals.

**The Brush Beryllium Co.** has opened a West Coast plant in Hayward, Calif. It will supply machined beryllium components to the aerospace and nuclear industries.

**Chromalloy Corp.** has moved into a 43,000 sq ft plant in West Nyack, N. Y.

**Telerad Manufacturing Corp.** has expanded into a 20,000 sq ft building adjacent to its plant in Flemington, N. J.

**Lockheed Electronics Co.** is now occupying a "Systems Research Center" in Bedminster Township, N. J. Work here will include study programs on advanced areospace concepts.

**Perkin Elmer Corp.'s** Vernistat Div. now has a facility in Los Angeles for sales in the West.

**Horkey-Moore Associates** have expanded Testing Div. facilities to include a Fluids Contamination Analysis Lab.

**Bowmar Instrument Corp.** recently added a 23,000 sq. ft. addition to its Fort Wayne plant. It will handle machining and heat treating of ultra-precise components.

**Convair - Astronautics** is completing a 68,400 sq. ft. electronics manufacturing facility in San Diego.

## Contracts

**Boeing Airplane Co.** — $247-million for work on the Air Force's hardened and dispersed Minuteman.

**The Martin Co.** — $30-million for work on Pershing system.

**Northrop Corp.** — $28-million for design, development and production of automatic checkout systems, gyroscopes, periscopes, and radiometric sextants for Polaris.

**Remington Rand Univac**—$26-million for production and testing of electronic ground guidance computers for Titan.

**Lycoming Div., Avco Corp.**—$20,213,292 from Aeronautical Systems Center for T55-L-5 and T53-L-5 gas turbine engines.

**The Martin Co.**—$18,853,460 for Army's Lacrosse missile system.

**Western Electric Co.**—$18-million for Army Nike Zeus work.

**General Electric Co.**—$15,500,000 to develop a new Missile Trajectory Measurement System (MISTRAM) for monitoring guidance performance of missiles launched at the Atlantic Missile Range.

**Pratt & Whitney Div., United Aircraft**—$11.2-million Navy contract for continued development of the J-52 turbojet.

**Convair Div., General Dynamics**—$8,176,000 from the Army for continued development of the Mauler air defense missile system.

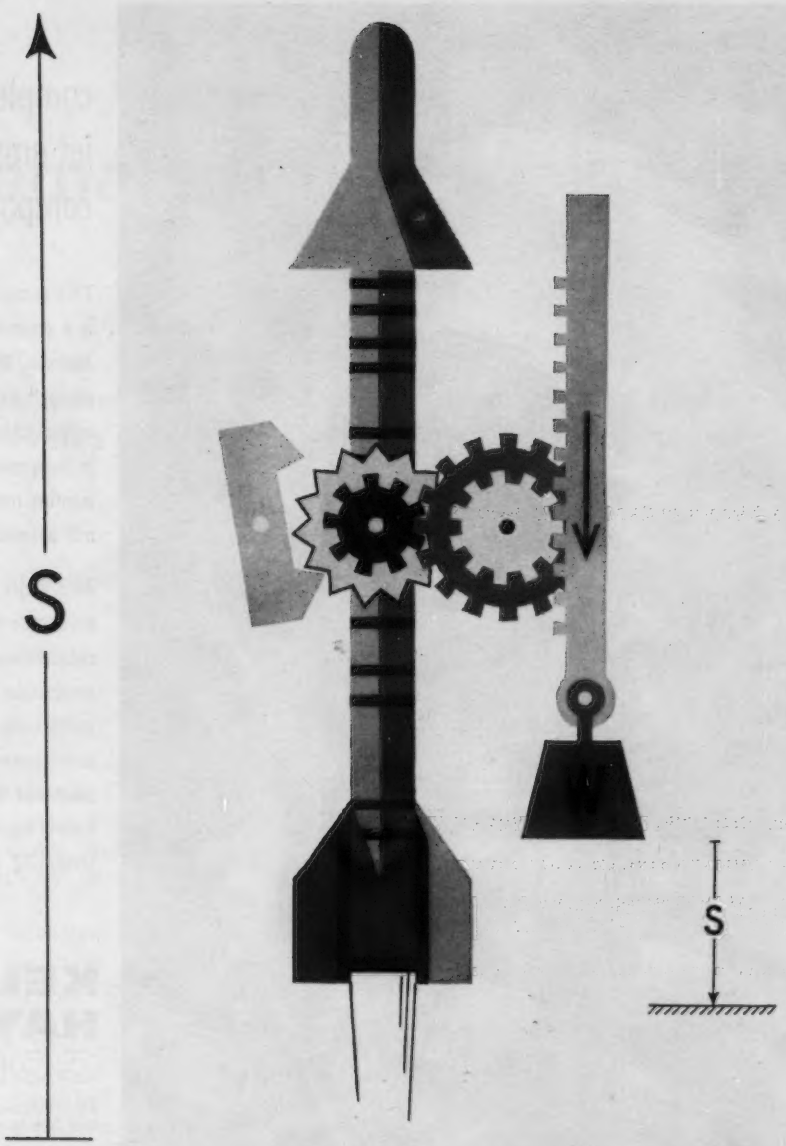
**Sperry Rand Corp.**—$7-million for the Sergeant missile system.

**Continental Electronics Manufacturing Co.**—$7-million in subcontracts for super-power radar transmitters for the Army's Nike Zeus.

**Douglas Aircraft Corp.** — $5,478,696 for components and other equipment for MB-1 "Genie" rocket; $3,880,000 for production of a new multiple bomb rack adapter for the Navy's A4D Skyhawk attack bomber.

**The Marquardt Corp.** — $1.5-million subcontract from Columbus Div., North American Aviation, for design and fabrication of a ramjet propulsion system for Army supersonic target missiles; $1.2-million for two missile launch trainers for Green Quail and Hound Dog.

**Aero Hydraulics Div., Vickers Inc.**—$1.7-million to produce integrated battery - powered Auxiliary Power Units for nozzle control units on Minuteman stages.




## Bulova escapement used as an integrating accelerometer

Bulova's unusually creative teams of scientists and engineers play an ever increasing role in the vanguard of precision design and development. Consider the nature of a Bulova escapement; it's generally employed as a second-order integrating accelerometer. However, the basic mechanism lends itself equally well to rotational motion of unbalanced rotors in an accelerating field.

The drawing above shows an inertial element, or weight, coupled to a runaway escapement by a rack. A safe-arm latch locks the system until missile launch. Under acceleration the escapement will delay the weight from moving through its stroke, $s$, according to the following:

$$(1.) \qquad t = \sqrt{\frac{K}{ag}}$$

Where $t$ is the time for the weight, $W$, to traverse its stroke, $s$, under an acceleration $a$, $K$ is the mechanism constant which takes into account the gear ratio; the moment of inertia of the system as reflected at the pallet wheel; and the number of pallet cycles involved during stroke $s$.

If the acceleration is constant, the change in distance of the missile during $t$ is

$$S = \frac{1}{2} agt^2$$

or

$$(2.) \qquad t = \sqrt{\frac{2S}{ag}}$$

Equating (1) and (2)

$$\sqrt{\frac{2S}{ag}} = \sqrt{\frac{K}{ag}} \qquad S = 2K$$

It is thus evident that, for a given escapement with a given stroke, the distance integrated is constant, and is independent of acceleration.

Bulova developments in the field of time measurement are particularly significant because they advance the state-of-the-art with existing systems and elements . . . with existing components of proven reliability and accuracy. But, continuing study of new concepts keeps Bulova systems years ahead—ready to meet the future needs of both the military and industry.

BULOVA

Research & Development Laboratories, Inc.
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## complex jet engine componentry

This complete jet turbine wheel is a product of Kelsey-Hayes, Jackson, Michigan plant. Its high standards of performance reflect Kelsey-Hayes' capabilities in the production of crucial rotating machinery, components and assemblies.

As a major subcontractor to the aerospace industries, Kelsey-Hayes' capabilities also include the production of vacuum-induction-melted alloys, as well as design, development and production of advanced thrust vectoring devices.
Kelsey-Hayes Company,
Detroit 32, Michigan.

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# Minuteman In The Making

**First-stage development at Thiokol—Utah geared around mobility; Intent to evolve on-site casting techniques apparent**

**By John P. Kushnerick**

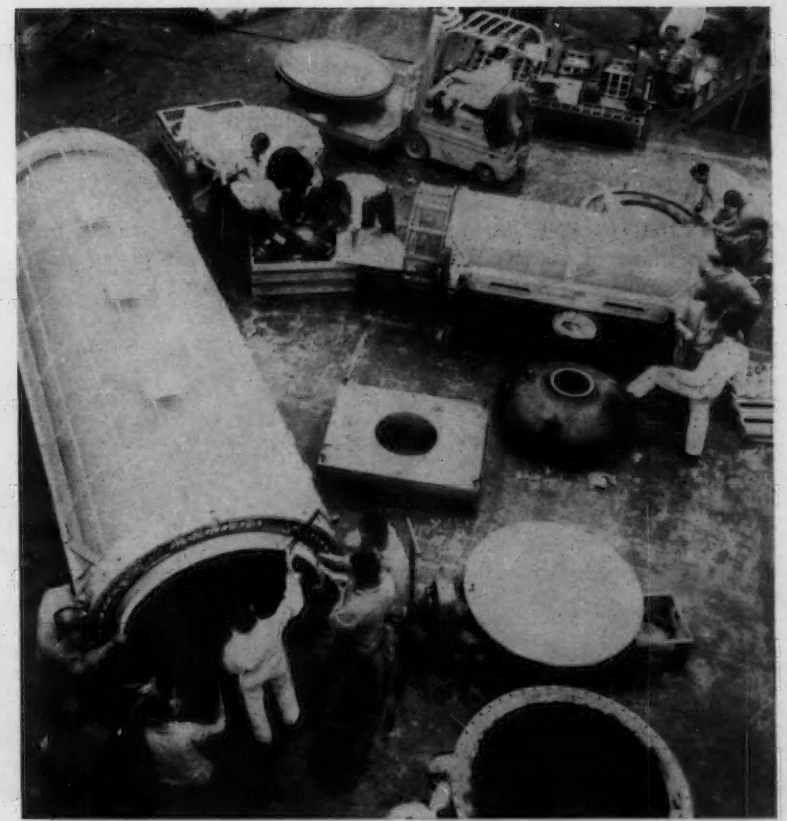
On a barren 11,000 acre tract near Brigham City, Utah, polybutadiene acrylic acid is mixed with its Thiokol binder and poured into high-strength steel cases. Solid-fueled rocket motors are in the making.

The cases are "incubated" in carefully engineered "holes in the ground" to cure the propellant. From this underground nest are "hatched" first stage motors for Minuteman.

After Air Force "marries" all three stages, the first Minutemen will again sit and wait in "holes in the ground" at Malstrom AFB. Concrete silos are being constructed here for the first Minuteman base.

Anticipating practically no countdown, and no serious storage problems, Minuteman is from start to finish Air Forces "ace in the hole."

Though first stage producer Thiokol already refers to the booster as "small," it is the biggest solid propellant engine to go into production. The Minuteman team is trying hard to sell its missile's capability for space tasks. They are having trouble. One of the biggest obstacles is "unselling certain influential elements in the U. S. space



**HARDWARE INSPECTION** is phase one of Minuteman first stage assembly and loading. Thiokol subcontracts fabrication of high-strength steel cases (Ladish D6 AC). Case is housed in special steel "cage" for handling.

## Propellant mixed indoors in 300 gas tanks, Transported to outdoor pits in casting cans

program that the word liquid-fueled is not an inherent part of the definition of a rocket booster."

There is no assembly "line" at Brigham City. Processes are being developed and improved concurrently with production.

The flexibility of existing equipment at Thiokol's R & D shop is indicative of what can be expected in the soon to be built plant 78 for full production. Further refinements of full techniques and equipment will no doubt find a place in the on-site loading concept Thiokol is planning.

First-stage Minuteman assembly sequence is roughly as follows:

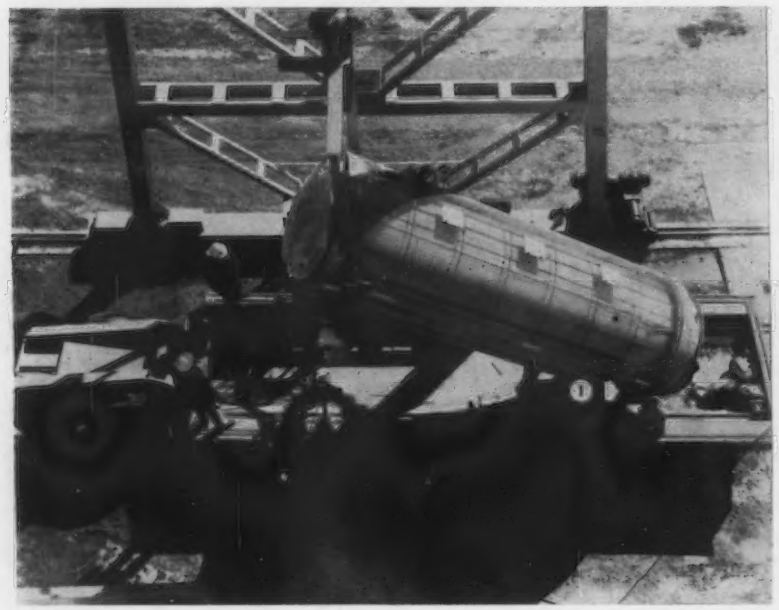
- Inspect incoming hardware (cases, etc.). Thiokol designs cases, but subcontracts all fabrication.
- Hand-paint or sling-spray liner to case and cure. Liner is same basic chemical as propellant, but is modified to give better bond with the motor case.
- Move cases to outdoor loading pits. A special handling cage or sling is used to protect the case. Special GSE transrector called "grasshopper" moves cases and elevates them to overhead traveling crane which then lowers unfilled motor into pit.
- Insert mandrel into case.
- Roll rail mounted casting house over pit.
- Remove propellant batch (PBAA) from mixer and load into casting cans.
- Transport casting cans by truck to casting house.
- Discharge, under pressure, propellant into case.
- Cure several days and remove mandrel. Length of cure can be regulated by varying heat.

Both nozzle-end, and head loading have been tried with success. Head loading looks better for large multi-million lb thrust solid rockets.

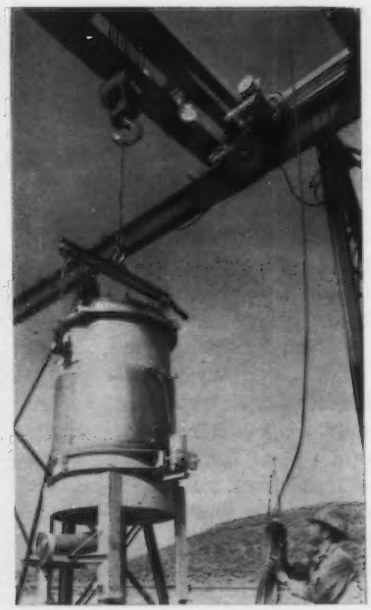
*more pictures next page*

**PROPELLANT MIX,** meanwhile, is dumped from 300 gal mixer into casting can. Can is beneath grid work of floor. Vacuum in can aids rapid loading. Propellant is polybutadiene acyrilic acid (PBAA).

**TRAVELING CRANE** lifts Minuteman case, with liner installed, from transport trailer at outdoor loading and curing pits. Case pivots at (1) to vertical position, is then lifted free of trailer and lowered into pit.

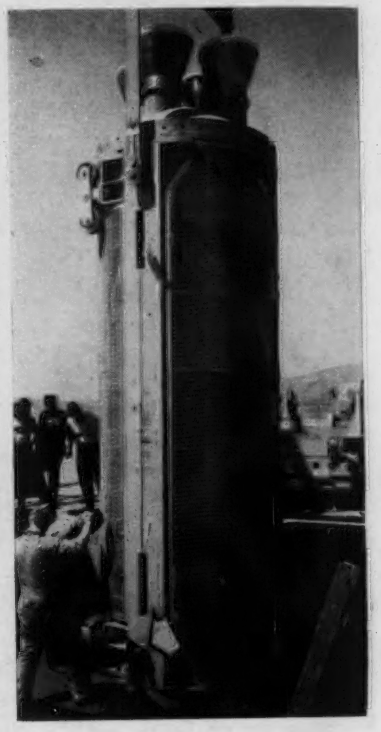


**AT LOADING PIT,** casting can is positioned over Minuteman and propellant is pressure fed into case.



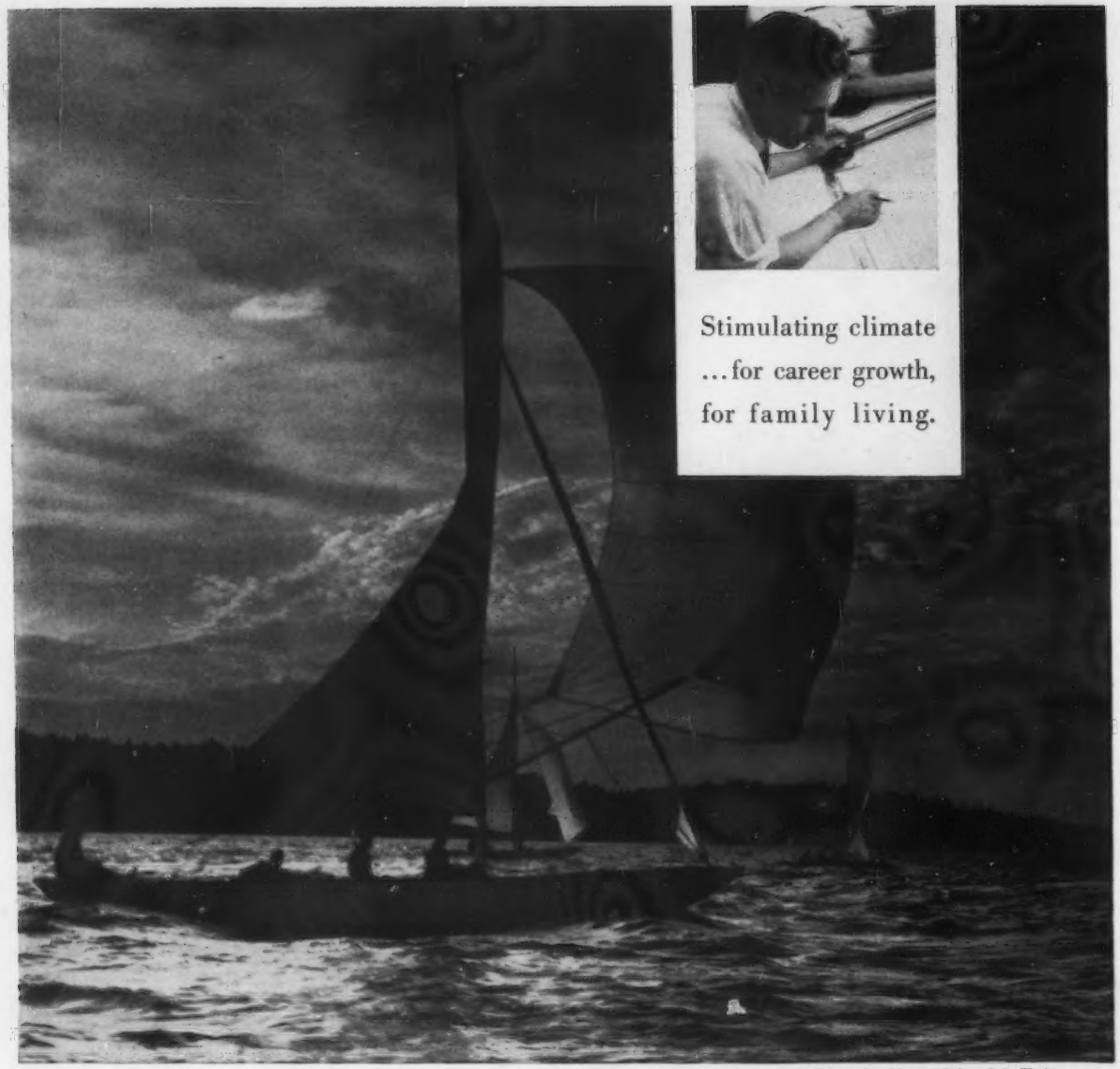
**KEY SPOT** in the loading operation is the casting house. It moves on rails from pit to pit with all equipment needed to load Minuteman. Here, technicians prepare to screw end closure on nozzle end of motor.

**OUT OF THE PIT** comes loaded and cured first-stage motor. Pivot trunnion used to lower case to horizontal position on transporter is clearly visible. (arrow).



**MOUNTING NOZZLES** on loaded Minuteman case is one of last steps in final assembly. Nozzles have shown negligible erosion in full duration firing tests.

**"GRASS HOPPER"** transrector can be used at cast pit or for loading first stage on long distance transporters. The auxiliary handling equipment can lift up to 100,000 lb.





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TRANSPORT DIVISION **BOEING**

# JPL's Plan To Explore Space

**Ranger research vehicle seen as bus hauling scientific "passengers" to Moon, Mars, Venus; To use Agena B and Centaur versions of Atlas**

**By Dan Schneiderman,** Engineering Group Supervisor, Spacecraft Integration, JPL

Ranger is now in the hardware development stage. This space-vehicle is Jet Propulsion Lab's first response to the assignment of exploring Moon and the planets.

Ranger's mission is clear: arrive at some point in space, perform a scientific act, and relay information back to Earth.

Initial launch vehicle will be Atlas Agena B combination. This will allow a spacecraft weighing between 600 and 800 lb. Ranger will be approximately 12 ft long, and six ft in diam at its hexagonal base.

First flights are scheduled for next year. The initial effort will concentrate on perfecting the various engineering elements of the machine to achieve reliability for later flights. Among other things, these first flights will involve attempts to achieve long operating life in the hostile space environment.

Systems have been designed that will achieve full attitude stabilization and in-course corrections of the trajectory.

These two developments are notable achievements over the techniques used in the past, where weight restrictions made it necessary to use elementary spin stabilization to stabilize the payload in flight.

**Severe Environments**—The physical design of a spacecraft is constrained by a unique contradiction. It must operate for a great majority of its lifetime in vast space at zero gravity and in a hard vacuum. But, for a relatively short period during launch, it must withstand high acceleration vibrations, gravity forces and physical confinement.

Exploring Moon and the planets presents other severe problems. These are: extremely hard vacuums, types and quantities of radiation about which we are just beginning to learn, and sterilization of equipment which will land on the Moon. The latter, of course, is necessary to avoid contamination of the lunar surface with life cultures from Earth. We are also concerned with sterilization techniques that will apply to equipment which someday will return to the Earth. Consequently, sterilization techniques developed in the Ranger program will be useful in protecting the Earth from contamination as the program advances.

**Scientific Bus**—We look upon the spacecraft as a "bus" which can carry different kinds of "passengers," represented by varying scientific equipment, to different destinations and drop them off according to their destination and desires.

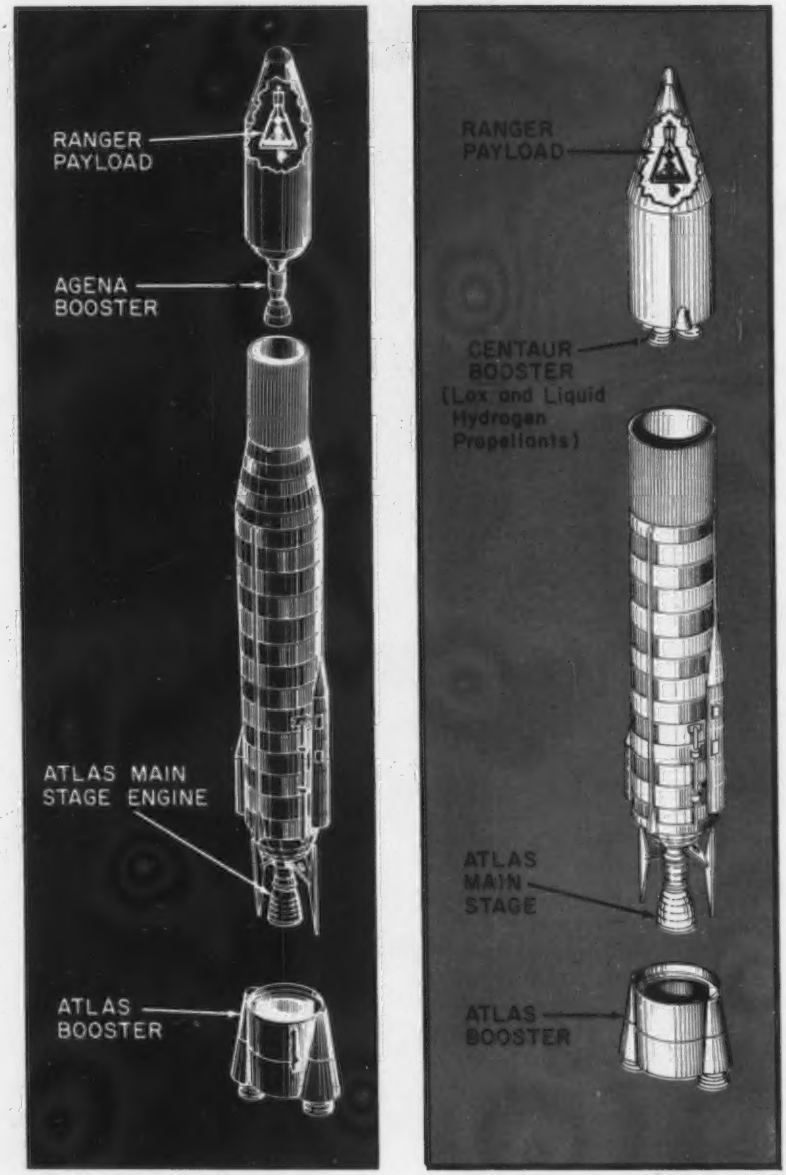
For this purpose, the basic "bus" consists of a hexagonal structure which mates to the vehicle that launches it and upon command separates and flies through space. The "passengers" bolt to the upper part of the hexagonal structure and can be changed easily from flight to flight.

The first flights will carry as "passengers" scientific instruments geared to obtain a comprehensive survey of the radiation fields in space and the factors that influence them.

Fig. 1 shows some of the scientific "passengers" which will be carried on these first engineering flights, together with the systems that will stabilize the spacecraft and allow it to make three-axial maneuvers in the acquisition of the Sun, to provide solar power, and the Earth, to send data back via a directional antenna.

In subsequent flights, this same

## First flights to Moon in 1961; Mars mission includes infrared mosaic of planet




**ATLAS-AGENA B** (left) is useful at lunar distances; however, it cannot carry significant loads up to the velocities necessary to reach either Mars or Venus. The Atlas-Centaur configuration (right) will be called to do this job. The spacecraft for such planetary missions will use the same basic elements being developed in the Ranger series. They will be based again on the "passenger bus" concept.

basic bus will be used to carry a capsule which will rough land on the lunar surface to conduct seismic experiment.

**Moon Mission** — The rough-landing lunar capsule is now being constructed under contract with JPL by the Aeroneutronic Division of the Ford Motor Company, Newport Beach, Calif.

In the lunar capsule flight, the flexibility of Ranger as an all-purpose "bus" is demonstrated. (See Fig. 2.) The upper frame support, which carried scientific instruments in the first flights, will be removed and replaced by the 300-lb lunar capsule. The capsule will be mounted on the basic hexagonal shape of the bus.

An in-course propulsion system will be added to the "bus" to provide a maneuver part way out in the trajectory to insure lunar impact. As the "bus" approaches the Moon, about 66 hr after launch, it will orient itself so that a television camera can take a series of pictures of improving resolution as the "bus" approaches the Moon.

The "bus" also will carry a gamma ray spectrograph which will allow preliminary analysis of the composition of the lunar surface.

Approximately 20 mi from the surface of the Moon, the lunar capsule will be separated from the spacecraft. Its solid retrorocket will fire and the capsule will be slowed to something under 300 mph as it impacts the lunar surface. The "bus" itself will continue on in and destroy itself as it crashes into the moon at approximately 6500 mph. The TV camera will not operate after separation of the capsule from the spacecraft.

Inside the lunar capsule will be a smaller survivable capsule containing the instrumentation. It will weigh approximately 50 lb and will be protected by crushable structures from impact damage.

Instrumentation will consist of a thermometer to measure the temperature of the capsule, and a seismometer to measure Moon quakes or meteoritic impact. The capsule also will contain its own power

supply, transmitter and directional antenna to provide information to the Earth for 30 days.

**Beyond The Moon**—While the Atlas Agena B is useful at lunar distances, it cannot carry significant loads up to the velocities necessary to reach either Mars or Venus. We are looking forward to the Atlas Centaur configuration to do this job. The planet spacecraft will use the same basic elements being developed in the Ranger series. They will be based again on the "passenger-bus" concept.

When this version of Ranger makes its trip past Venus, it will carry scientific instrumentation to learn more about the atmosphere of Venus, and perhaps penetrate that atmosphere to learn more about the planet itself. Typical of the instruments which could be carried on board such a Venus spacecraft are: (1) Ultra violet spectrograph, (2) Light polarization detector, (3) Passive (temperature) radar, (4) Active radar, (5) Magnetometer, (6) Solar corpuscular radiation analyzer, (7) Cosmic ray detector, (8) Infrared scanner.

**Infrared Mosaic of Mars**—When the spacecraft makes its trip past Mars, in place of the passive and active radar experiment, it probably will carry equipment to obtain a detailed infrared picture mosaic. The picture will be broken up into a number of reasonably small squares, and the infrared response within that square will be indicated. Thus, it should be possible to determine something about the forms of plant life which appear to exist on Mars. In addition, the Mars spacecraft probably will take a visual photograph of that planet from a few thousand miles away and increase in this manner our detailed knowledge in the visual spectrum of Mars.

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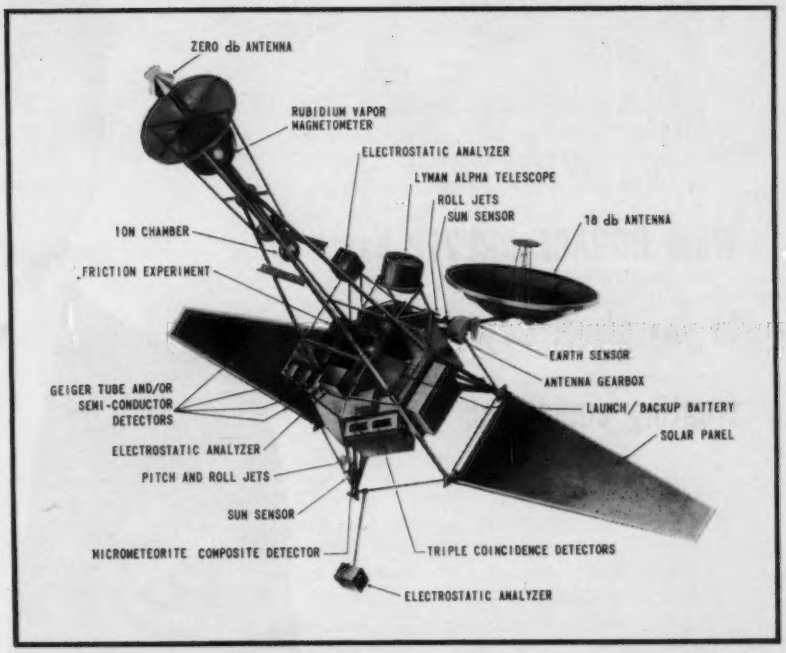



**FIG. 1. SCIENTIFIC "PASSENGERS"** of the Ranger research vehicle are identified, together with the systems that will stabilize the spacecraft. Stabilization will play a vital function by enabling the vehicle to make three-axial maneuvers in the acquisition of the sun, to provide solar power, and Earth, to send data back via a directional antenna.

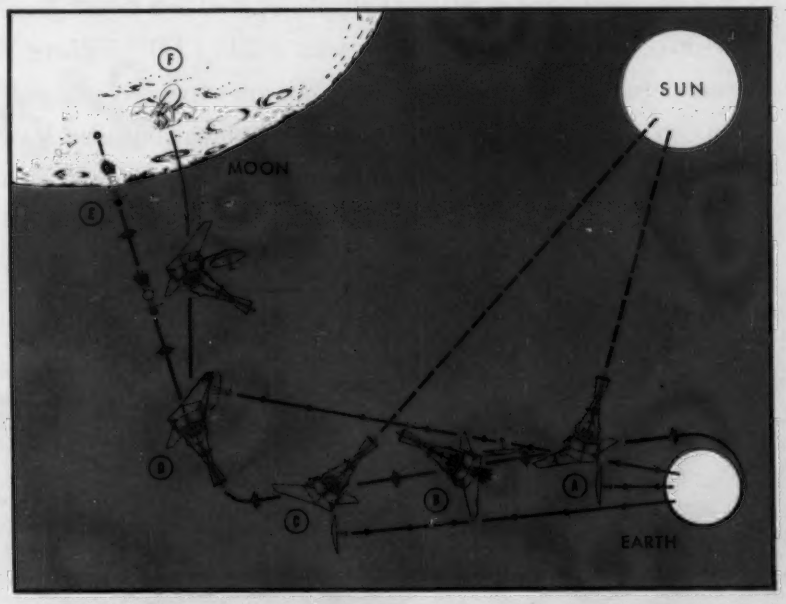



**FIG 2. IN LUNAR-CAPSULE FLIGHT,** the flexibility of Ranger as an all-purpose "bus" will be demonstrated. The upper frame support, which carried scientific instruments in the first flights, will be replaced by a 300-lb lunar capsule. The capsule will be mounted on the basic hexagonal shape of the vehicle. An in-course propulsion system will be added to the "bus," to provide a maneuver part way out in the trajectory to insure lunar impact.

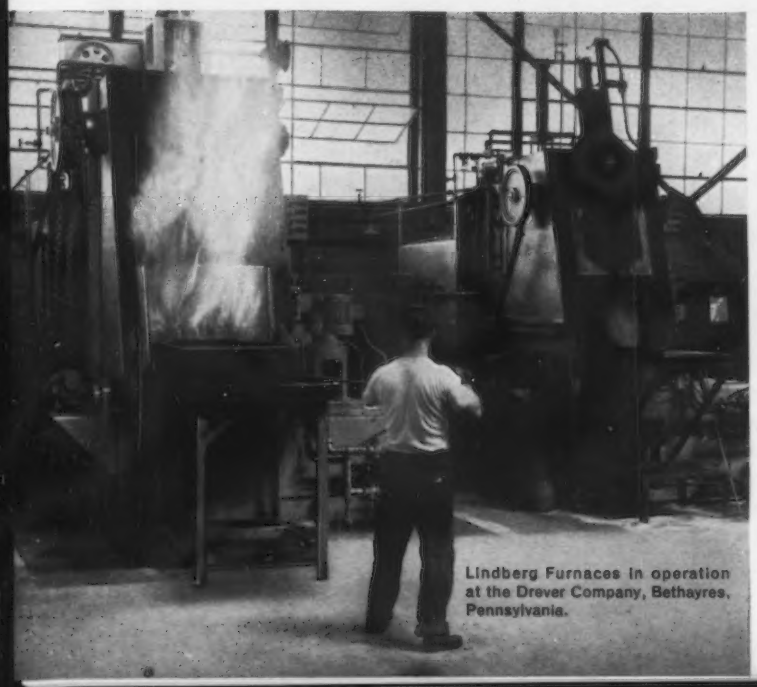
# What HORACE DREVER has to say about Lindberg heat treating equipment

*Mr. Horace Drever, internationally prominent in the industrial heating field, is a Past-President of the Furnace Manufacturers Association and President of Drever Company, furnace manufacturers and commercial heat treaters.*

**QUOTE** from Mr. Drever's unsolicited letter to Lindberg Engineering Company

"For the past three and one-half years, we have been operating one of your Type 243618 GVRT Furnaces along with a 500 CFH Lindberg Hyen generator in our commercial heat treating division. We are extremely pleased, not only with the fine quality of work turned out by this equipment but also its relatively trouble-free operation. As evidence of our complete satisfaction we have ordered another Lindberg Furnace of this type."

DREVER COMPANY



Lindberg Furnaces in operation at the Drever Company, Bethayres, Pennsylvania.

We are happy that Mr. Drever, a furnace manufacturer in his own right, originally chose Lindberg equipment for his heat treating plant and that its satisfactory service prompted an additional order. The second Lindberg Furnace is now in production at Drever Company, as the adjacent photo shows. Bless those satisfied customers! If you have a product or process in the metal or ceramic field requiring the application of heat you can depend on Lindberg's engineering and design know-how to provide exactly the right equipment to answer your need. Get in touch with your nearest Lindberg Field Representative (see classified phone book) or write direct to Lindberg Engineering Company, 2473 West Hubbard Street, Chicago 12, Illinois. Los Angeles plant: 11937 South Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg, Ltd., Toronto.

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# Autonetics Machine Shop Handles Prototype and Production Runs

## Management feels production quality is increased by exposing production workers to prototype tolerances and techniques

By Philip Geddes

The Central Operations Department of Autonetic's machine shop produces detail guidance system parts for both prototype and manufacturing efforts. In many instances, subcontractors are called in to learn with the prime contractor, and the job is then farmed out. Complex precision work, however, is retained at Autonetics.

Pre-prototype machining is done in a special shop in the engineering department. Prototype machining is done in Central Operations to insure that the shop "understands or learns" a job before production. In general, Central Operations' machines are capable of production runs but most runs are small. Jigborers, the aristocrats of machine tools, are used as pieces of production equipment for running fine tolerances. At the side of the jig borers stand a row of Borematics, also running to tenths, (0.0001 in.) on a production basis. Supervision feels that the jig borer operator is not down-graded by doing production work. Rather, the skill level of other operators in the shop is raised by being exposed to the precision undertaken there.

**Gear Making**—Every gyro system has gears. How fine some of these are can be seen by looking at a typical gear cut in the shop:

Fine Pitch Worm Gear cut on pressure angle of 20 deg.
Involute base circle diam 0.9572 in.
Circular pitch . . . . . 0.0500 in.
Number of teeth . . . . . 64
Class per ASA B6
11-1951 . . . . . P3 precision
Total composite
error . . . . . 0.00025 in. max
Tooth composite
errors . . . . . 0.0002 in. max
Profile surface finish . . 16 micro in.

Fine gears demand fine machines. Typical are an Illinois Fine Pitch Gear Generator and a Pfauter (German) Gear Cutter. The number of foreign produced machines in the work shop is noticeable. The Illinois machine has a capacity of 3 in. with infinite pitch. Scope of the tool is not confined by pitch hobs. Pitch desired, within range of machine, is selected. The cutter is changed to suit job—the machine does the rest.

**FIG. 1. ALUMINUM SAND CAST** gear housing with 20 line-bored holes, checked with air gage.

**FIG. 2. INTERMEDIATE GIMBAL** made from aluminum casting is jig bored in multiple setup at Autonetic's machineshop. Bore diameters are held to 0.0002 in. tolerance. Concentricity to 0.003 in.

**DOUBLE WALLED** aluminum casting mount being machined on Kearney & Trecker horizontal mill. Autonetics retains more complex jobs in its own shop.

**DEBURRING OPERATION** of guidance components takes place under powerful stereoptic microscope. Rubber-mounted wheels and carbide tools are used.

Fine gear checking is done with an electronic Kodak "Conju Gage" capable of measuring to 50 millionths in total composite error, involute form, and lead error runout. In the machine, a master worm rack fits against the gear to be tested. A tape record shows the results obtained. Comparative readings between the Conju Gage and a second measuring machine are obtained with a Schoppe and Faeser (German) fine pitch gear checker. By checking one gear a day between the two machines the accuracy of the electronic machine used for rapid production checking can be determined.

**Boring** — Typical example of boring work in the shop is that performed on an aluminum alloy sand cast gear housing. It has 20 line bored holes with typical dimensions as follows:

10 bores . . . . . 0.2497 in.
+0.0000, —0.0002 in.

2 bores . . . . . 0.6250 in.
+0.0002, —0.0000 in.

1 bore . . . . . 1.0000 in.
+0.005, —0.0000 in.

The set up for this job is illustrated (Fig. 1). Up to ten parts have been run at once using this technique.

On the aluminum gimbal also shown in a multiple setup, (Fig. 2), the bore diameters are held from 0.0002 to 0.0005 in. tolerance, and concentricity to 0.003 in. The bores must be parallel within 0.0005 in. over the 14-in. length.

**Grinding**—In the lap grinding department more examples of precision machining abound. As an example, the journal for a fluid bearing made of 440 steel has a full diam of 1.968 +0.005 in. Thickness of the two mated parts is 0.250 +0.0000 —0.0005 in. On the journal, a 0.001 in. relief must be ground within 50 millionths tolerance, flat to five bands of light on interferometer. Rough grinding is accomplished on small rotary grinder by Taft Pierce, lapping on a Lapmaster, and polishing on a jury rig. Parts are deburred under Bausch and Lomb stereoptic microscopes, by extremely patient girls using small rubber-mounted wheels and carbide tools.

Crush grinding is used in multi-diam parts. On a small gyro rotor spindle no more than 2 in. long, a Sheffield machine grinds nine diameters in one pass, not counting chamfers. Finish machining to 0.0002 in. diam is accomplished on another machine after screw threading the ends.

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# Guide To Lower Costs and Reduce Vehicle Weight

**"Use new design and procurement data to select proper sheet materials" . . . Johnson of Convair**

**"Then apply thickness data to make sure you don't add extra weight through loose tolerances" . . . Hoffman of RAND**

## HOW MUCH WOULD YOU SPEND TO SAVE A POUND OF WEIGHT?

**By R. E. Johnson,** Design Engineer
Convair Fort Worth

One method of comparing structural materials has been to use strength - to - weight ratios. The method gained such prominence that designers plotted strength-to-weight ratios of aluminum, steel, and titanium for elevated temperatures. Materials were specified with no other thought than to save weight. In more recent times, however, the designer has become acutely aware of another factor which ranks equally with the strength of the material. This factor is cost.

**Designer, Buyer Roles**—Design groups often have incomplete or obsolete cost data. Because their end purpose is different, the designer and buyer work in different areas. Communications between the two concerning new sources of material, changes in base price, or quantity extras often break down. Once the material is spelled out on the drawing, it is rarely changed except as a result of design error. For a material cost saving program to be successful, the cost consideration must, therefore, be taken into account before the material callout on the drawing. For this reason, many companies in the aircraft and missile field are educating designers through Cost Manuals, Cost Bulletins, and cautions in the Materials or Design Manual as to the relative costs of the newer materials.

If there is a design choice, the cheaper or more accessible material should be used, and data should be available to aid in the choice.

This article presents such cost data side-by-side with the strength-to-weight ratios for some of the more common materials used in aircraft and missiles. It is not the purpose of the article to make some materials look good or bad from a cost standpoint; other characteristics of a material often offset its high initial cost. A good example of this is titanium. It would not be advisable to rule out titanium on the basis of its high initial cost for use where corrosion resistance is important. Using another material which has a low initial cost but which requires a coating or similar protection might very easily run the cost up above that of titanium.

**Cost Data**—The costs used in this analysis are base prices on materials at the time of writing. Prices do not include any variations resulting from the quantity ordered. This factor, can be a very important one, but it is not possible to include it in this analysis, since the amount used will depend on the project. Another cost factor not included is that of testing or certification to a material specification. This again depends on the individual company requirement.

Cost of sheet material increases rapidly as the gage decreases. This is shown graphically in Fig. 1, and is particularly true for materials difficult to roll to thin gages. For example, if we are interested in obtaining commercially-pure titanium strip of thickness less than 0.000125 in., we should be aware that the thickness extra for this gage is $258.00/lb. On the other hand, this $258 pound of titanium in this thickness and 24 in. wide is theoretically 2085 in. long.

Majority of data indicates that the best material to use from a cost standpoint is aluminum. Structures personnel will immediately advise that aluminum service temperatures are below 400°F. Except for some of the newer experimental alloys that carry aluminum's temperature up to 600° at reduced strength, this is true. But, these alloys cost more

and, in most instances, require an ingot order.

**New Ratio Explained**—To compare the strength-to-density values with cost data, a ratio of strength/density-cost was calculated for several materials using 0.080-in. thick sheet. The units of this ratio work out as in.-lb/dollar.

Table I shows this ratio for several alloys of aluminum, steel, and titanium at room temperature. The highest numbers represent the best "value" considering cost. The best alloy in each material category was chosen for graphical representation of values at temperatures up to 800°F. These were the 2024-T86 aluminum, 301 full-hard steel, and 4Al-3Mo-1V STA titanium alloy. Normal presentation of strength-to-weight is shown in Fig. 2 at temperatures up to 800°F. In contrast, the plot of "value" units vs temperature is shown in Fig. 3. Note that in Fig. 2, titanium shows a comfortable margin over the other two materials. However, when cost is considered, titanium runs a poor third at all temperatures. Below 400°F, the "value" of aluminum is superior to the other materials, while above 400°F, steel shows an increasing margin over the aluminum.

**Arguments** — There are arguments to this data. First, due to complexity of making aircraft and missile parts, raw-material cost represents a small fraction of the finished part cost. It is also plausible to argue that titanium should not be included in this comparison since it is an "infant" in the metals field. It is true that the cost of titanium is coming down each year with increased production and improved know-how, but advanced space vehicles need the newer materials such as titanium, beryllium, super alloys and the like, and designers need to have some idea of the price they are paying for the weight saving. Choice of materials will still depend on individual application and the answer to the question, "How much can I spend to save a pound of weight?"

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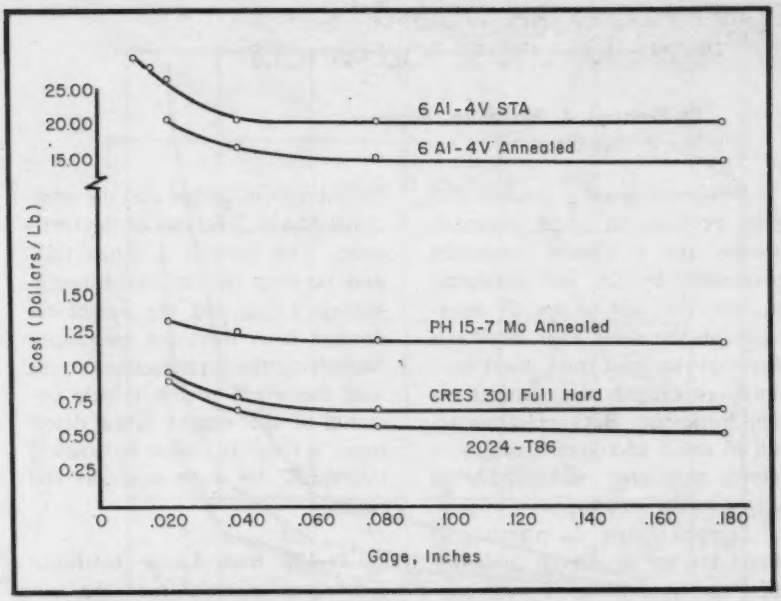


**FIG. 1. SHEET-MATERIAL COST** rises rapidly as gage increases.

**TABLE I**

**Room Temperature Strength/Cost—Density Ratio For 0.080 in. Sheet Material**

| Material | Strength (PSI) | Density Lb./cu. in. | Cost Dollars/lb. | Ratio Strength/ Cost-Density |
|---|---|---|---|---|
| 2024-T86 | 72,000 | 0.100 | .584 | $12.35 \times 10^5$ |
| 7075-T6 | 72,000 | 0.101 | .627 | $11.35 \times 10^5$ |
| Cres 301 Full Hard | 185,000 | 0.286 | .713 | $9.08 \times 10^5$ |
| PH 15-7 Mo Annealed | 150,000 | 0.276 | 1.22 | $4.45 \times 10^5$ |
| 17-7PH Annealed | 150,000 | 0.276 | .963 | $5.64 \times 10^5$ |
| 6 Al-4V Annealed | 130,000 | 0.160 | 15.25 | $0.530 \times 10^5$ |
| 6 Al-4V STA | 160,000 | 0.160 | 20.45 | $0.489 \times 10^5$ |
| 4Al-3Mo-1V STA | 185,000 | 0.163 | 20.45 | $0.554 \times 10^5$ |

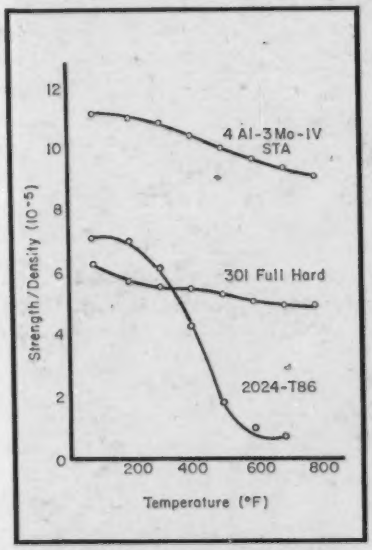


**FIG. 2. STRENGTH-TO-WEIGHT** ratios are compared up to 800°F.

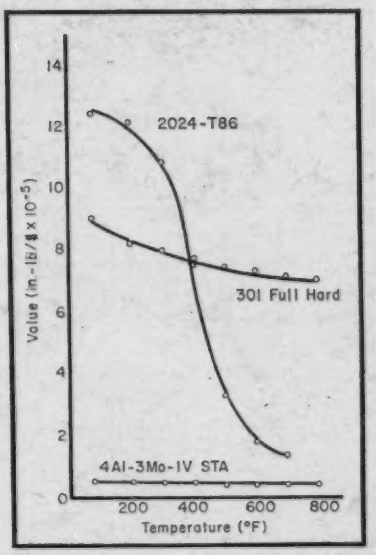


**FIG. 3. "VALUE" UNITS** vs temperature are shown plotted.

# DON'T ADD EXTRA WEIGHT BY SPECIFYING LOOSE TOLERANCES

**By George A. Hoffman,** Engineer
The RAND Corp.

Designers usually assume that most portions of sheet materials possess the minimum properties guaranteed by the mill producer. So, they are apt to specify tolerances on the sheet gage in such a way that the least thick sheet used equals or exceeds the nominal design thickness. Both practices result in small additional margins of safety; both also add extraneous weight to the structure.

In specifying the number of sheets for use in aircraft and missiles, one is confronted with conflicting alternatives:

- A liberal tolerance reduces costs and speeds up delivery.
- A tight tolerance raises costs but helps to reduce weight.

This article presents a criterion by which the problem of tolerance specification can be solved. The method is based on measuring both the extraneous weight and the additional cost as functions of the tolerance. This permits a direct relation between the increased manufacturer's cost and the weight reduction from tightened tolerances. Identifying the manufacturer's cost with the worth to the vehicle operator of the weight saved determines a range of "most economical tolerances" for most materials and gages.

**Weight from Loose Tolerance**
Extraneous material (i.e., the material beyond the thickness required by the design) results from: (a) Variation in the thickness of the sheet along the rolling direction—experienced from sheet to sheet, and to a lesser extent, within a sheet; (b) variation in the thickness of the sheet perpendicular to the rolling direction—sometimes resulting in thin edges and a high center, called a "crown."

**Extra Cost from Tight Tolerances**—Deviations from the required thickness of sheet can be held to a minimum by a number of methods. A few of these are listed in order of successively higher cost increments over commercial tolerance sheets:

(1) Inspecting "all-over" sheets rolled to commercial tolerances (±0.006 for 0.063 gage), retaining, say, one half of the sheets with the best tolerances and reprocessing the remaining worse half. This procedure finds many a precedent in the large-scale scrapping for special reasons in aircraft production involving aluminum and titanium. By judicious inventory of these gaged-all-over sheets, tolerances may be reduced to ±0.002 for 0.063 gage by selecting the best-dimensioned half of the sheets. Cost is $.650/sq ft.

(2) Rolling in special high-precision mills specifically designed to produce very accurate thickness. Such mills might yield 0.063-gage sheets with ±0.001 tolerance. Cost is $17.00/sq ft.

(3) Sheet and plate skin grinding down to ±0.0005 in special mills (still in the design stage).

**Criterion for Choosing**—Fig. 1 and 2 show, that both cost and overweight can be functionally related, by cost analysis, to the same variable tolerance. If an index or figure of merit were somehow devised for the value to an aircraft or missile operator of eliminating one pound of overweight, then it would be possible to read off directly from Fig. 3 the "optimum" tolerances on any thickness and type of sheet material.

There is a great range of opinion as to the worth or value to the aircraft operator of a pound of weight saved. A list will indicate the width of the divergence: (a) The figure of $2065/lb has been mentioned for a commercial piston-engine transport, (b) the figure of $600 to $800/lb has been derived for an American jet transport, (c)

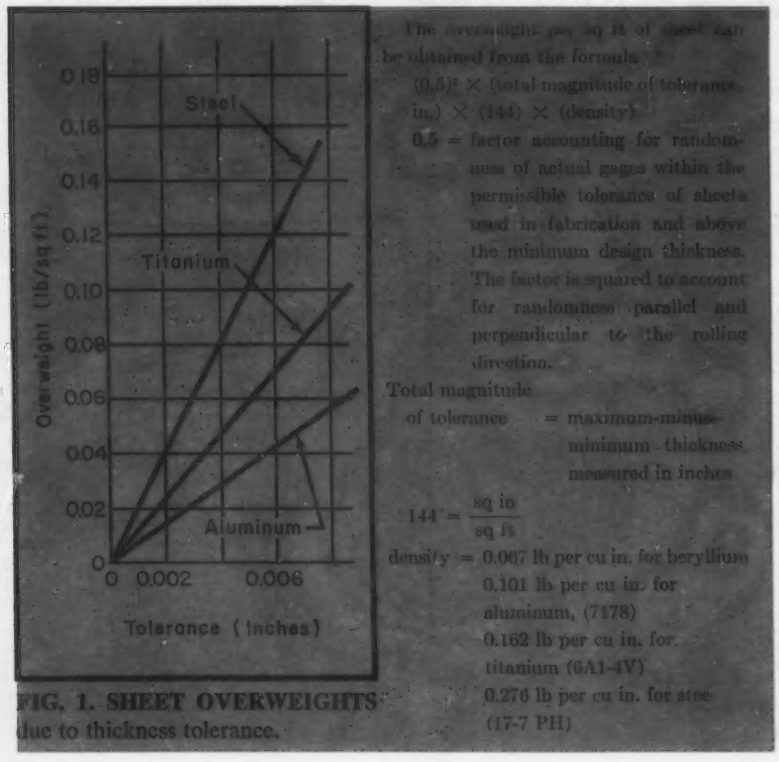


**FIG. 1. SHEET OVERWEIGHTS** due to thickness tolerance.

The overweight per sq ft of sheet can be obtained from the formula

$(0.5)^2 \times$ (total magnitude of tolerance, in.) $\times$ (144) $\times$ (density)

0.5 = factor accounting for randomness of actual gages within the permissible tolerance of sheets used in fabrication and above the minimum design thickness. The factor is squared to account for randomness parallel and perpendicular to the rolling direction.

Total magnitude of tolerance = maximum-minus-minimum thickness measured in inches

$144 = \frac{\text{sq in}}{\text{sq ft}}$

density = 0.067 lb per cu in. for beryllium
0.101 lb per cu in. for aluminum, (7178)
0.162 lb per cu in. for titanium (6A1-4V)
0.276 lb per cu in. for stee (17-7 PH)

figures of $560 to $840/lb have been used for a British jet transport, $220/lb for a fighter-interceptor, and $98/lb for a British propjet transport, (d) space vehicles are most sensitive to extraneous weight — in actual experience it costs about $30,000 to place one lb of payload into orbit in Explorer I, and about $15,000/lb for Explorer IV.

Because of this spread in estimated values, rays from $50 to $1000/lb are plotted in Fig. 4 for the worth of weight reduction in flight structures.

A criterion can therefore be formulated. For a wide range in the worth of a pound, there is only a narrow spread in the economically-optimum tolerance. As an example, in the "worth" range of $200 to $500/lb saved, Fig. 4, aluminum and steel tolerances on 0.063 sheet can be specified to be ±0.001 in., while titanium tolerances appear to be between ±0.0015 and ±0.002.

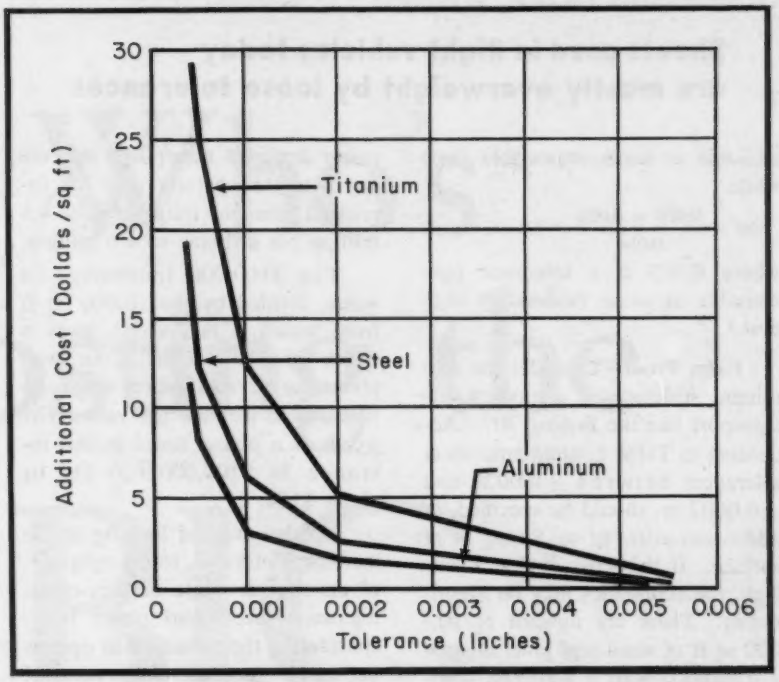


**FIG. 2. ADDITIONAL COST** involved in tolerance control of 0.063 x 36 x 96-in. sheets.

**Summary**—The desirable tolerances for steel and aluminum (±0.001) and titanium 0.063 sheet (±0.002) are sensitive to the annual production quantities of each material. The incremental cost of high-precision titanium sheet is inversely proportional to the lb/yr produced. Therefore, if the planned yearly poundages of titanium are revised significantly upward or downward, target tolerances should accordingly be revised, but in the opposite sense. The result is that if the 30,000 lb per year used in figuring the additional cost involved in tightened tolerances is raised, for example, to 100,000 lb/yr, the optimum tolerance would be reduced to ±0.001. On the other hand, if the 30,000 lb/yr is lowered to 10,000 lb/year, then the tolerance would go up to ±0.003.

The main conclusion of this article is apparent from Table 1; namely, that the economically-optimum tolerances of all sheets of all materials are consistently smaller than those readily available at present in the aircraft and missile industry. It should be of major concern to realize that, in all instances, sheets used in flight vehicles today are overweight by excessively loose tolerances.

Expenditures influence structural weight in the manner of the more commonly-studied factors, such as the configuration of structural elements and the material used. For example, a sufficient expenditure increase when purchasing sheets could reduce structural weight by 3.6 to 5.3 per cent in a titanium-sheet structural component. (If the design thicknesses were 0.056 in., commercial sheet would have to be procured at 0.063-in. gage, ±0.006 in. The percentage of reducible overweight would then be

$$100 \times \frac{0.006 - 0.004}{0.056} = 3.6 \text{ per cent,}$$

where 0.004 in. is a tolerance pur-

*continued on next page*

**TABLE 1 OPTIMUM TOLERANCES OF SHEET FOR VARIOUS THICKNESSES AND PRODUCTION LEVELS**

| Sheet thickness | Beryllium | | Titanium | | Aluminum (at present production levels) | | Steel (at present production levels) | |
|---|---|---|---|---|---|---|---|---|
| | 10,000 lb/yr (assumed) | 50,000 lb/yr (assumed) | 30,000 lb/yr (assumed) | 100,000 lb/yr (assumed) | Optimum | Commercial | Optimum | Commercial |
| 0.002 | 0.0003 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0003 | 0.0002 | ..... |
| 0.020 | 0.0015 | 0.0012 | 0.0015 | 0.0010 | 0.0007 | 0.001 | 0.0008 | 0.002 |
| 0.063 | 0.0050 | 0.0030 | 0.0030 | 0.0020 | 0.0020 | 0.004 | 0.0020 | 0.006 |
| 0.125 | 0.008 | 0.005 | 0.006 | 0.004 | 0.003 | 0.005 | 0.004 | 0.010 |
| 0.250 | 0.012 | 0.008 | 0.009 | 0.006 | 0.005 | 0.013 | 0.005 | 0.017 |

## Sheets used in flight vehicles today are mostly overweight by loose tolerances

chasable at some reasonable cost: while

$$100 \times \frac{0.006 - 0.003}{0.056} = 5.3 \text{ per cent,}$$

where 0.003 is a tolerance purchasable at some moderately high cost.)

**Extra Proof**—Consider the aluminum structure of a modern jet-transport like the Boeing 707. According to Table 1, aluminum sheet tolerances between ±0.0020 and ±0.0007 in. should be specified, at additional cost up to $2/sq ft of surface. If this cost at first seems high, the economics may be illuminating. There are upward of 10,000 sq ft of sheet and plate in such a transport, with a weighted commercial (average) tolerance of ±0.006 in. Reduction to, say, ±0.0015 would save (0.006 — 0.0015) × 144 × 10,000 × 0.101 = 650 lb.

This 650 lb saved permits passenger capacity to be increased in one model from 88 to 90 by simply installing two more seats in the already designed transport. But the worth to the operator now has increased from the initial cost of 4.5 million per airplane to 4.6 million.

The $100,000 increment in value, divided by the 10,000 sq ft from which it is derived, gives a worth of $10 per sq ft, or well above the $2/sq ft worth originally paid out to increase the value. The worth of a pound saved in this instance is $100,000/650 lb, or about $154/lb.

Another way of looking at the increment in value, to the operator, of an aircraft made of very-close-tolerance sheets and plates is by considering the reduction in operating costs. Assume, conservatively, that the 650 lb saved is used by the operator only to reduce fuel-consumption expenditures. Over the life of the transport, fuel cost savings will amount to $44,000.

$$12 \times 3650 \times \frac{650}{18} \times 1.2 \times \frac{0.15}{6.5} = \$44{,}000$$

where 12 = years in use by operator before resale of craft.

$$3650 = \left(365, \frac{\text{days}}{\text{years}}\right) \times (10 \text{ hours in daily use})$$

650 = lb of weight saved by reducing tolerances from ± 0.006 to ± 0.0015

18 = average $\frac{\text{lift}}{\text{drag}}$ ration for this aircraft

1.2 = thrust specific fuel consumption, $\frac{\text{lb of fuel/hr}}{\text{lb of thrust}}$

0.15 = cost of JP-4 fuel "in the plane," dollars/gallon

6.5 = lb of fuel per gallon, lb/gallon

The $44,000 figure gives a worth for the tightened tolerances of $4.4/sq ft, while the worth of a pound saved in this case is $\frac{\$44{,}000}{650 \text{ lb}}$ or about $68/lb, from reduced fuel costs alone.

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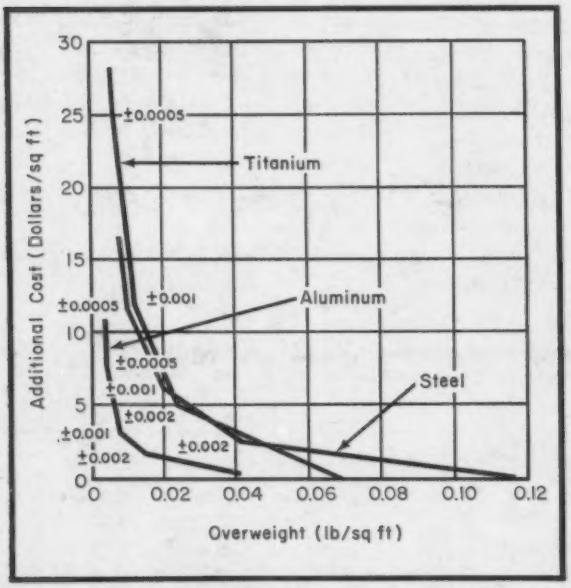



**FIG. 3. RELATIONSHIP** between additional purchasing costs and overweight in sheets.

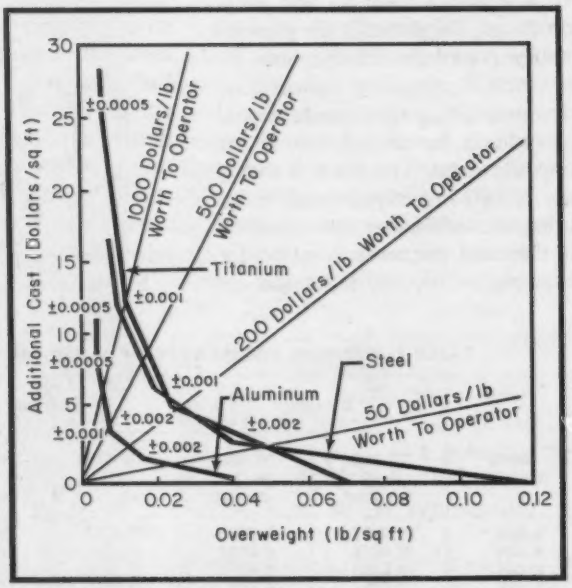



**FIG. 4. WORTH-OF-POUND** plots given for choosing economically optimum sheet tolerances.

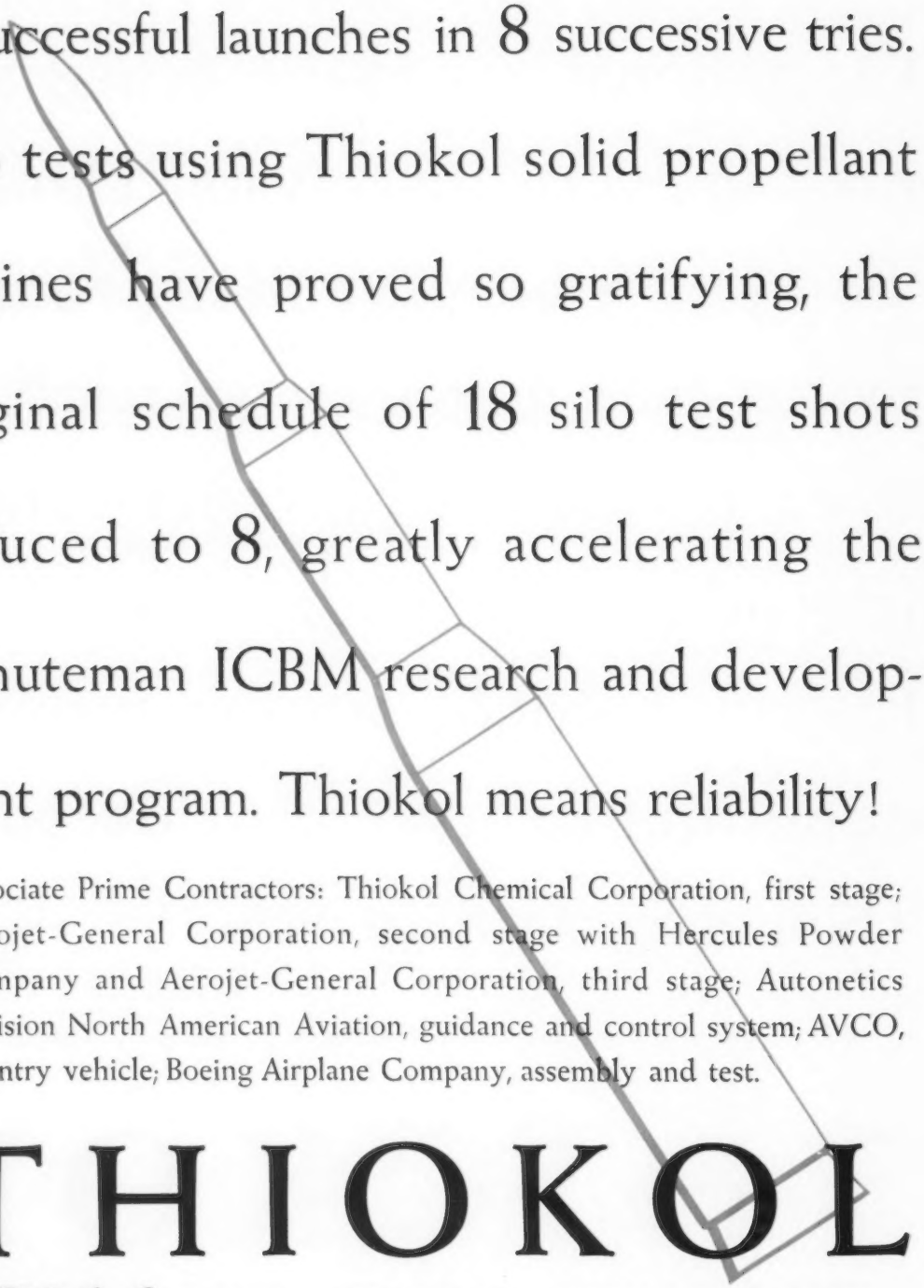


Circle 18 on Inquiry Card ⟶

# Who's posting the BIG SCORE on reliability in propulsion?

# MINUTEMAN

8 successful launches in 8 successive tries. Silo tests using Thiokol solid propellant engines have proved so gratifying, the original schedule of 18 silo test shots reduced to 8, greatly accelerating the Minuteman ICBM research and development program. Thiokol means reliability!



Associate Prime Contractors: Thiokol Chemical Corporation, first stage; Aerojet-General Corporation, second stage with Hercules Powder Company and Aerojet-General Corporation, third stage; Autonetics Division North American Aviation, guidance and control system; AVCO, re-entry vehicle; Boeing Airplane Company, assembly and test.

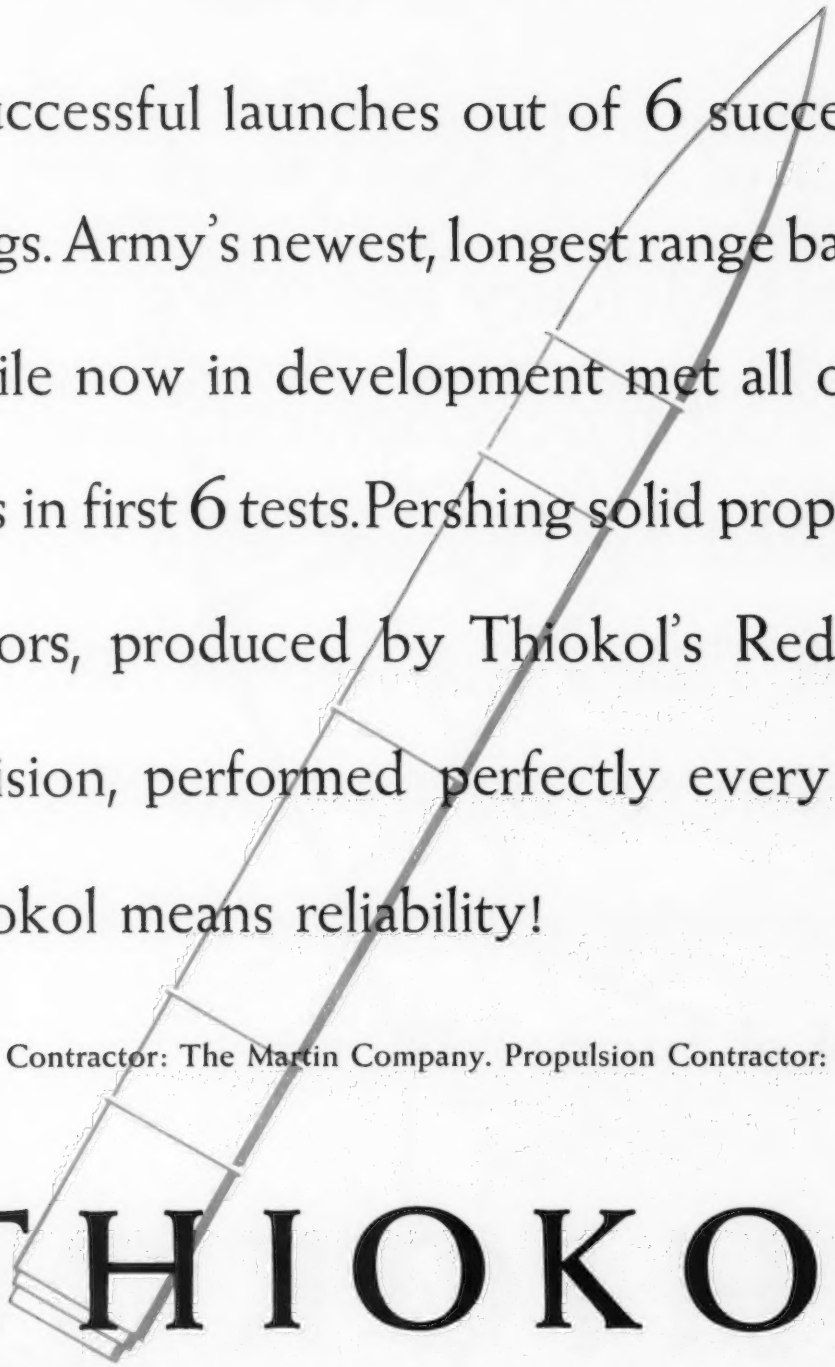
# THIOKOL

Thiokol® CHEMICAL CORPORATION, BRISTOL, PENNSYLVANIA

Rocket Operations Center: Ogden, Utah

Minuteman Motors produced at the Utah Division

# PERSHING



6 successful launches out of 6 successive firings. Army's newest, longest range ballistic missile now in development met all objectives in first 6 tests. Pershing solid propellant motors, produced by Thiokol's Redstone Division, performed perfectly every time. Thiokol means reliability!

Prime Contractor: The Martin Company. Propulsion Contractor: Thiokol.

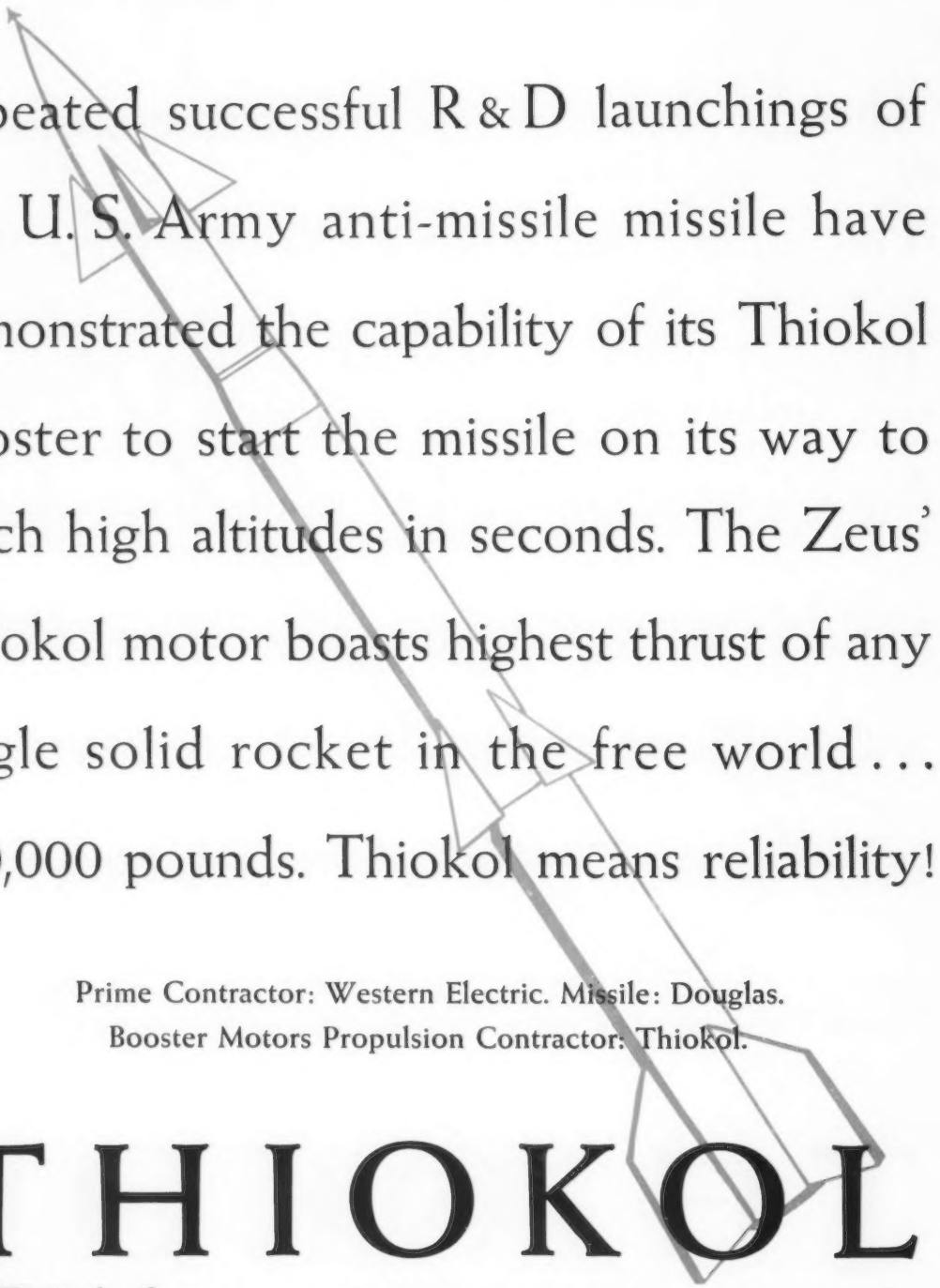
# THIOKOL

Thiokol® CHEMICAL CORPORATION, BRISTOL, PENNSYLVANIA

Rocket Operations Center: Ogden, Utah

Pershing Motors produced at the Redstone Division

# NIKE-ZEUS



Repeated successful R & D launchings of the U. S. Army anti-missile missile have demonstrated the capability of its Thiokol booster to start the missile on its way to reach high altitudes in seconds. The Zeus' Thiokol motor boasts highest thrust of any single solid rocket in the free world . . . 450,000 pounds. Thiokol means reliability!

Prime Contractor: Western Electric. Missile: Douglas.
Booster Motors Propulsion Contractor: Thiokol.

# THIOKOL

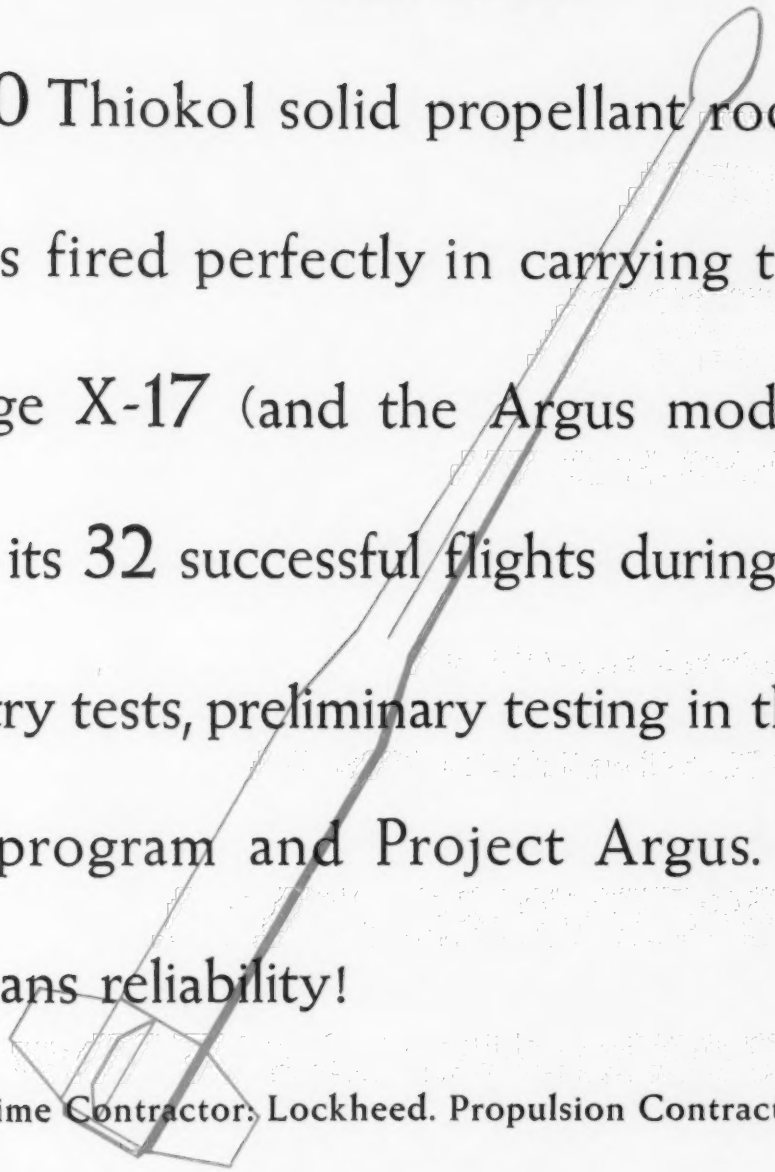
Thiokol® CHEMICAL CORPORATION, BRISTOL, PENNSYLVANIA

Rocket Operations Center: Ogden, Utah

Nike-Zeus Motors produced at the Redstone Division

# X-17

160 Thiokol solid propellant rocket motors fired perfectly in carrying the three stage X-17 (and the Argus modification) on its 32 successful flights during vital reentry tests, preliminary testing in the Polaris program and Project Argus. Thiokol means reliability!



Prime Contractor: Lockheed. Propulsion Contractor: Thiokol

# THIOKOL

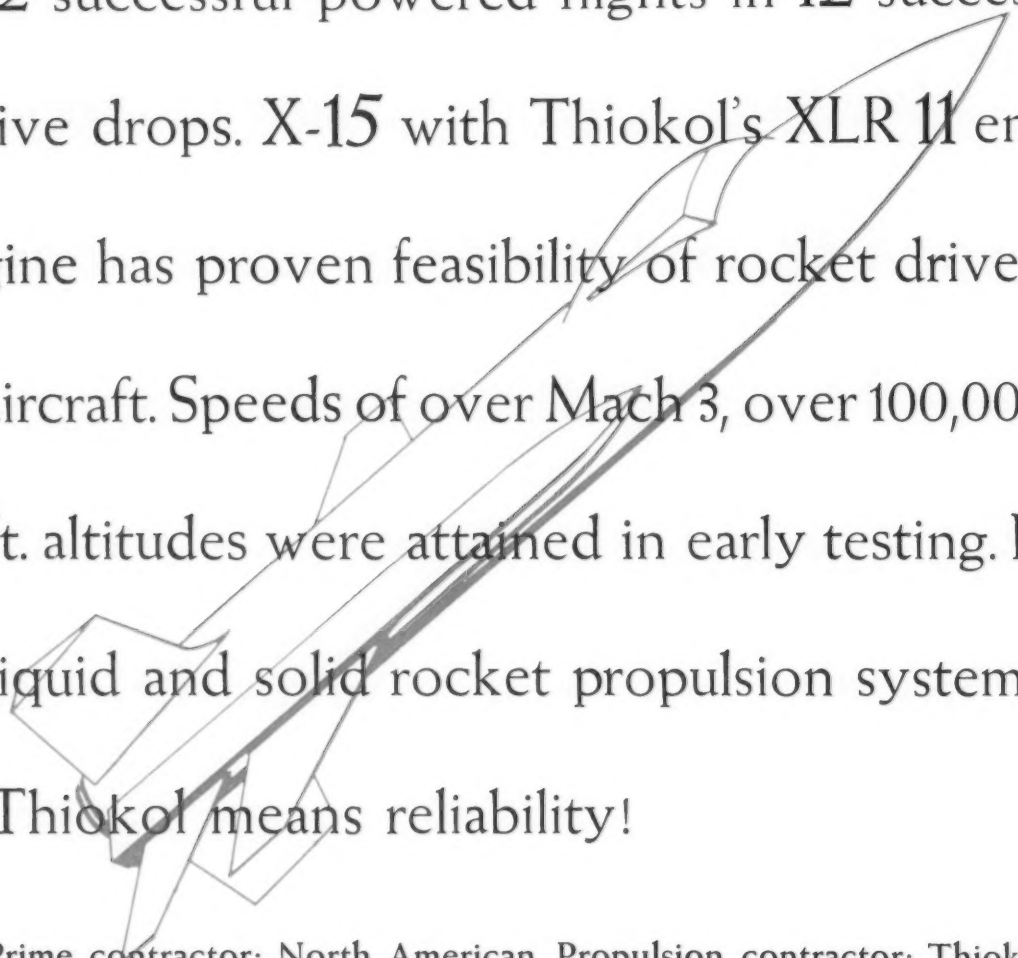
Thiokol® CHEMICAL CORPORATION, BRISTOL, PENNSYLVANIA

Rocket Operations Center: Ogden, Utah

X-17 motors were built by the Redstone and Elkton Divisions

# X-15

12 successful powered flights in 12 successive drops. X-15 with Thiokol's XLR 11 engine has proven feasibility of rocket driven aircraft. Speeds of over Mach 3, over 100,000 ft. altitudes were attained in early testing. In liquid and solid rocket propulsion systems, Thiokol means reliability!



Prime contractor: North American. Propulsion contractor: Thiokol.

# THIOKOL

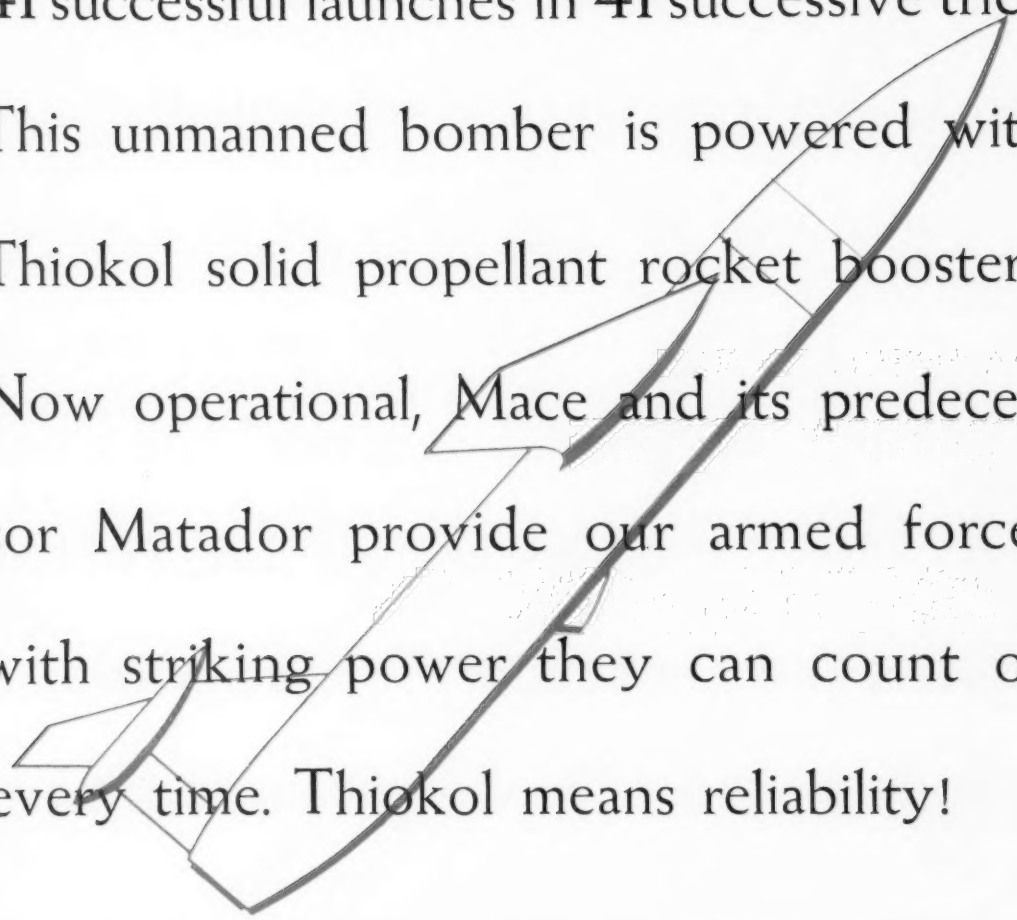
Thiokol® CHEMICAL CORPORATION, BRISTOL, PENNSYLVANIA

Rocket Operations Center: Ogden, Utah

X-15 engine produced at Reaction Motors Division

# MACE

41 successful launches in 41 successive tries. This unmanned bomber is powered with Thiokol solid propellant rocket boosters. Now operational, Mace and its predecessor Matador provide our armed forces with striking power they can count on every time. Thiokol means reliability!



Prime Contractor: The Martin Company. Booster Contractor: Thiokol.

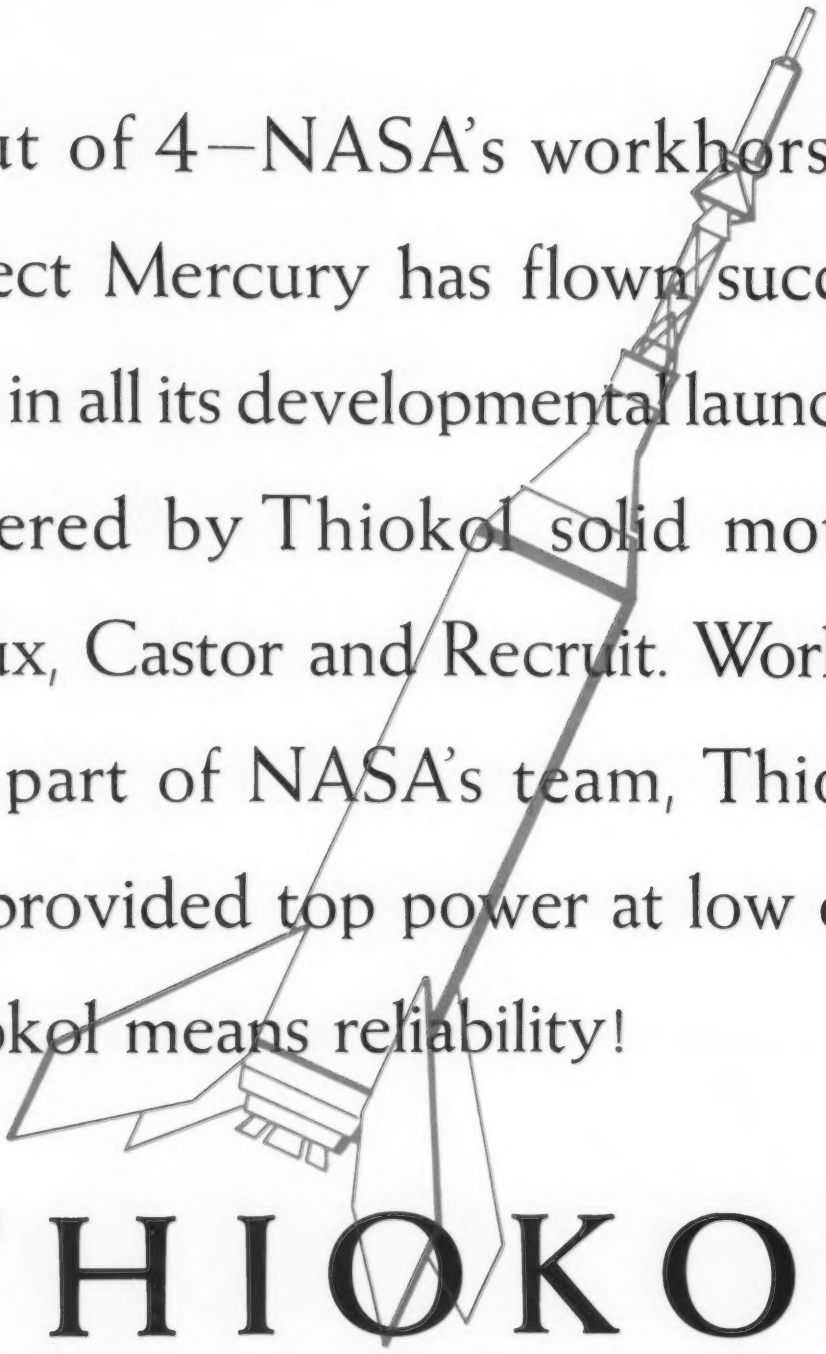
# THIOKOL

Thiokol® CHEMICAL CORPORATION, BRISTOL, PENNSYLVANIA

Rocket Operations Center: Ogden, Utah

Mace Motors produced at the Utah Division

# LITTLE JOE



4 out of 4—NASA's workhorse in Project Mercury has flown successfully in all its developmental launches, powered by Thiokol solid motors, Pollux, Castor and Recruit. Working as a part of NASA's team, Thiokol has provided top power at low cost. Thiokol means reliability!

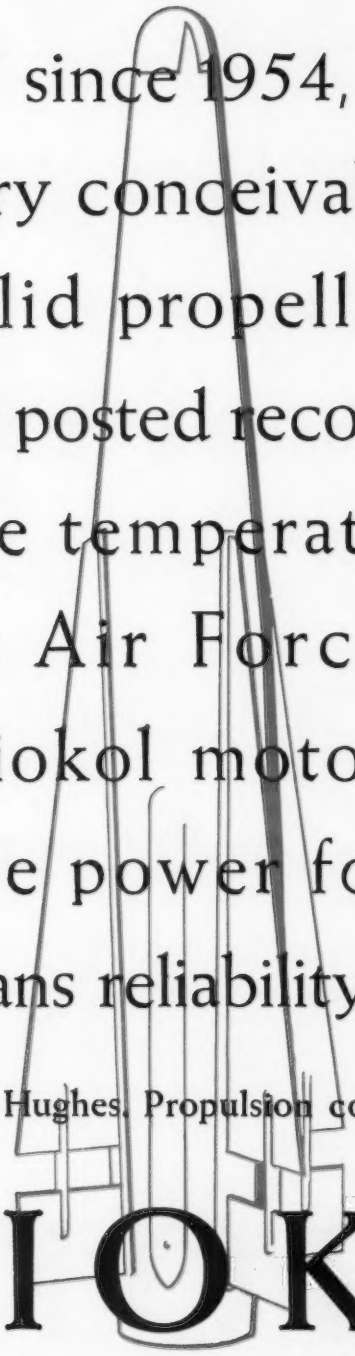
# THIOKOL

Thiokol® CHEMICAL CORPORATION, BRISTOL, PENNSYLVANIA

Rocket Operations Center: Ogden, Utah

Little Joe Motors produced at Elkton and Redstone Division

# FALCON



Operational since 1954, stored and fired in every conceivable climate, Thiokol solid propellant rocket motors have posted record reliability over a wide temperature range. In today's Air Force nuclear Falcon, Thiokol motors provide dependable power for defense. Thiokol means reliability!

Prime contractor: Hughes. Propulsion contractor: Thiokol.

# THIOKOL

Thiokol® CHEMICAL CORPORATION, BRISTOL, PENNSYLVANIA

Rocket Operations Center: Ogden, Utah

Falcon Motors produced at Elkton, Redstone and Longhorn Divisions

Thiokol®

# CHEMICAL CORPORATION

BRISTOL, PENNSYLVANIA

## Rocket Operations Center

**OGDEN, UTAH**

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Elkton, Maryland

Longhorn Division
Marshall, Texas

Nuclear Development Center
Parsippany-Troy Hills, New Jersey

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# Vicious Procurement Practices...? DOD Talks Back

**By G. C. Bannerman,** Director for Procurement Policy

*The editors of Aircraft & Missiles received this letter from the Dept. of Defense after publishing an article, in June 1960 which was critical of DOD Procurement Practices.*

*"Your letter of June 15, 1960, to the Honorable Thomas S. Gates, Jr., has been referred to me for reply. It concerns an article entitled 'Vicious Procurement Practices in DOD?' by Mr. Scott of the Garrett Corporation. This article is similar to the statement Mr. Scott made before the Subcommittee on Small Business and Government Procurement, Select Committee on Small Business, House of Representatives, during the hearings held by the Committee March 29-31, 1960. In addition to Mr. Scott, Messrs. Robert R. Lent of the Strategic Industries Association and John Marschalk, a consultant, also testified at the hearings. Their testimony had certain points in common, and, at the request of the Committee, we responded to these common points in a letter to the Chairman. You have our permission to publish this letter as a response to Mr. Scott's statement. Thank you for the opportunity afforded us to reply."*

There are five points in Mr. Scott's statement ("Vicious Procurement Practices in DOD," A & M June 1960) that require comment.

**(1) Redefinition** — It is stated that there is a need to redefine the term "proprietary data." The definition of proprietary data, which is stated in ASPR 9-201(b), is as follows:

*" 'Proprietary data' means data providing information concerning the details of a contractor's secrets of manufacture, such as may be contained in but not limited to his manufacturing methods or processes, treatment and chemical composition of materials, plant layout and tooling, to the extent that such information is not disclosed by inspection or analysis of the product itself and to the extent that the contractor has protected such information from unrestricted use by others."*

We are convinced that the "reverse engineering" aspect of the definition should be clarified so that government personnel will not classify data as "non-proprietary" just because the item can be reverse engineered with extensive engineering and financial effort. The cost to the Government of reverse engineering is a clue to the proprietary nature of such data. So is the time such an effort would take.

**Change Needed**—We recognize that the present definition is in need of change. Accordingly, if we are to retain the concept of "proprietary data," the definition must be sharpened so that it will include any data not readily revealed by the product itself rather than only that data which is incapable of being reverse engineered. While this will require a change in language, it does not require a change in intention. The words "is not disclosed" in the above definition were never intended to describe a process of expensive and detailed reverse engineering. The fact that they have been so interpreted dictates the necessity for a change in definition.

**(2) Protection of Drawings**—It is asserted that the government should give industry the protection of drawings and designs (whether or not proprietary) which industry gets when it deals with other industry.

This suggestion seems to embrace the idea that we would obtain privately developed drawings under an agreement that they will be protected like proprietary data solely because they were privately originated. It is urged that they should be used only for the specified purposes for which they were obtained. This would create rights against the Government as to the use of drawings which might not include any proprietary information.

At the moment, two pertinent and important objections to this proposal occur to us.

The first is that it would put our contracting agencies in the position of having in their files complete descriptions, usually in the form of manufacturing drawings, of items which they must purchase. In many cases the descriptions would not contain any information which could not readily be copied from the product. But the drawings would still be under contractual protection against use for competitive reprocurement. In some cases the Government's needs can be met by the use of performance specifications not containing any design data. However, where it is necessary for the government to buy an additional quantity of equipment which is of identical design, the result of this proposal would be that the government could: (a) develop its own drawings from the equipment itself, (b) purchase the equipment on the basis of samples, or (c) purchase the equipment from the original supplier on a sole source basis without competition. The first alternative (a) is generally unsatisfactory, because the Department is not staffed to prepare drawings based upon products we already own. The drawings would merely duplicate drawings containing no proprietary information which are already in our files. This would obviously be

## Terms of contract agreement must be read as a whole contract, not as separate requirements

extravagant. It would waste the taxpayers' money duplicating available information without giving any useful protection to inventors or innovators.

The second alternative (b) is subject to these basic objections: The sample has to be displayed in one or more public places throughout the country, thereby necessitating varying amounts of travel by prospective bidders. The sample cannot be carried off to the engineering departments or individual bidders and disassembled for analysis and measurement. Finally procurement on such a basis leads to very frequent disputes based on performance variations or deficiencies which occur even though the design is copied.

We are led directly to the third alternative (c), sole source procurement from the original supplier. The procedure in alternative three is very difficult for those of us who work for the Government to support. It is not easy to explain why we should buy, without competition, an item for which we already have full information adequate for competitive procurement, when such information is protected only by contract and would otherwise be in the public domain. If this third alternative is the desire of the Congress, a clear statement of this legislative intention would be most helpful.

The second objection to this proposal (government protecting drawing), stems from the fact that the government obtains information about products in many ways. We may make a series of contracts for a product and get drawings which are unrestricted under one of them with a restriction under the other. We may buy the product once with a restriction on the drawings with subsequent procurement by sample with drawings furnished without restriction from the second contractor. Or we may, in some cases, reverse engineer a product on which we had obtained drawings subject to restriction. Any of these situations where we should have a perfectly valid right to use the drawings for competitive reprocurement would nevertheless be likely to lead to dispute and litigation. There would always be the suspicion that we had misused the protected drawings and, in some cases, an inference which would be difficult to rebut might arise in litigation. If the information in the drawings cannot readily be ascertained by others from the product itself, as in the case of "proprietary data" under the present definition, it is possible to pin-point responsibility for the use of drawings. However, where the information is readily evident from an examination of the product, there will be disputes over the source of the data used in a subsequent procurement. Also, the firm which initially designed the product will not, in fact, get the protection, in the form of continued sole source procurement, which is actually sought as the end product of this proposal.

**(3) Conflicting Documents**—It is alleged that specifications (MIL-D-70327) and other subsidiary contract documentation requirements (MCP 71-673, SAR-400 and MCP 71-77) nullify the ASPR data policy.

Specification MIL-D-70327 Military Specification, Drawings, Engineering and Associated Lists (16 March 1959) covers engineering drawings and associated lists prepared by DOD and by contractors. Its use is mandatory for all military departments. It provides the standards for all engineering drawings received from prime contractors and subcontractors.

This specification calls out the requirements for the various uses for which drawings are bought such as procurement, manufacture, testing, inspection, overhaul and repair, etc. Paragraph 6.2 requires a statement of the type of drawings and their intended use. Proprietary data is acquired in accordance with the terms of contract or order pursuant to paragraph 3.8. This means that proprietary data will be acquired only in accordance with the data policy and clauses set forth in ASPR Section IX—Part 2.

MCP 71-673 is a Spare Parts Provisioning Document for USAF Aeronautical and Associated Equipment Contracts. This document prescribes the terms and procedures for the selection and furnishing of spare parts under a given contract.

MCP 71-77 (June 1959) entitled "Engineering Data Requirements for USAF Material and Services" establishes Air Force requirements for engineering data and microfilm.

SAE-400 (24 April 1958) entitled "Special Aeronautical Requirements, Supply Item Provisioning Document for United States Navy Production Contracts" is a document prescribing terms and procedures for selection of supply items and technical data related thereto in Navy contracts using the document.

To have any significance as a contractual requirement for furnishing data, these documents must first be incorporated by reference in a contract. When this is done, however, this requirement is subject to all of the terms of the contract. In consequence, the following results flow. First, if the documents are incorporated in a research and development contract, as described in ASPR 9-202.1 (c), that contract would contain (1) the Basic Data Clause, ASPR 9-203.1, and (2) the addition to the Basic Data Clause, paragraph (i), in ASPR 9-203.4. Under paragraph (f) of the Basic Data Clause the Government would receive unlimited rights to use all subject data as defined in paragraph (a) of the unlimited rights to use all subject data as defined in paragraph (a) of the clause which is delivered under the contract. Subject data may, therefore, include proprietary data; however, paragraph (i) eliminates the need for furnishing data, whether proprietary or not, if it pertains to a standard commercial item

or service offered for sale or sold commercially by any supplier, provided the item is identified as to source and its characteristics are furnished.

Furthermore, paragraph (i) of the data clause specifically excuses the prime contractor from furnishing proprietary data for other items developed at private expense and previously sold or offered for sale, or minor modifications thereof, which are incorporated as components in the product. This is applicable to subcontractors as well as to primes. Therefore, this clause specifically overrides the data requirements of MIL-D-70327, MCP 71-673, MCP 71-77, and SAR-400 as to such components. The terms of the contract agreement must be read as a whole contract, not as separate requirements. There is no contractual obligation on the prime contractor to obtain or furnish such excluded data.

With respect to a contract for supplies, not having research or development as one of its principal purposes, the (i) paragraph in ASPR 9-203.4 is not used. Instead the (i) paragraph in ASPR 9-203.2 is required. This is the "fail-safe" clause and was referred to in the testimony by that name. The "fail-safe" clause provides that, notwithstanding any Tables or Specifications which may be included in the contract, "proprietary data" need not be furnished unless it is suitably identified in the Schedule of the contract as being required. Suitable identification of "proprietary data" is not accomplished by class designation, nor is it accomplished by the use of MIL-D-70327, MCP 71-77, nor SAR-400 none of which identify specific "proprietary data" and none of which is included in the Schedule.

If the above is properly understood, it is hard to see how these subsidiary contract documents can be construed contrary to the express provisions of the required data clauses of the contract. It is up to informed Government and contractor personnel to see that this kind of contract administration does not occur.

For the benefit of vendors it also might be well to require primes in their purchase orders to state their contractual data obligations.

**(4) What Primes Need** — It is alleged that vendors are being forced by prime contractors to give up privately developed data so that primes can satisfy what they conceive to be their obligation to the Government.

Primes are under no obligation to deliver to the Government data which has been expressly excluded by the data clauses in their contracts. The fact that in a research and development contract, data is acquired subject to unlimited rights means only that unlimited rights apply to the data which is contractually required. There can be no limited rights in such a contract. Therefore, the purpose of the policy is served by exclusion of certain data from delivery requirements.

The flow-down of unlimited rights in data from the prime to vendors relates only to that data which is required by contract. That which is obtained under research and development contracts is with unlimited rights but the data clause has designated which data are not required. Obviously we do not get unlimited rights in data which is not required to be furnished at all. There is nothing to attach rights to. This must be understood by primes, their vendors and by Government personnel.

**(5) Two Sets of Drawings**—It is alleged that industry is forced to have two sets of drawings; one fully suitable for manufacture and the other having "proprietary data" omitted or blocked out of the drawing.

As has been already explained, the data policy applicable to supply contracts will frequently not provide information suitable for complete manufacture by the government nor for reprocurement from other firms. This is deliberately so. It results from the exclusion of "proprietary data." Accordingly, it was concluded, when Part 2 of Section IX was drafted, that, if we do not want drawings for manufacture by the government nor for reprocurement from others, there should be very little demand for manufacturing drawings for any purpose. Hence, it was stated in ASPR 9-202.1 that "It is the policy of the Department of Defense . . . to limit demands for data to that which is essential for government purposes. The activity responsible for initiating a purchase request . . . will carefully determine the use contemplated for the data to be acquired and will specify only such data as is determined to be necessary to satisfy such use . . ." This policy left us free to buy maintenance manuals, operational instructions, cataloging descriptions and the like but would not normally have required manufacturing drawings. Under such circumstances there would have been no question of a second set of drawings.

**Contemplated Action** — It is clear that many procuring agencies are still calling for manufacturing drawings in supply contracts. We do not feel that either we or our friends in industry have at hand adequate facts on which to appraise the validity of these government demands for manufacturing drawings.

To properly assess this question we are proposing an extensive survey of activities for which such a need for manufacturing drawings has been claimed. These activities will include some concerned with maintenance, cataloging, supply management, inspection, provisioning and the like. It is hoped that this survey will point the way for a more positive statement of our policy. It may eliminate the problem of two sets of manufacturing drawings by requiring either one complete set or no manufacturing drawings at all.

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# NASA's Project Echo —A Worldwide Laboratory Tool

**Passive satellite tests directed at studying feasibility of larger inflatable structures for improving communications**

**TELEMETRY RACK,** with folded pole-antennas is seen below magnesium container of Echo sphere. At orbit injection, antennas spring up and lock.

Channels for global communication are as overcrowded as the road networks around the world.

Project Echo is man's first attempt to seek a solution off the beaten channels. Credit for the first concrete recommendation on use of satellites for communication goes to John R. Pierce of Bell Telephone Labs. Bell, under contract to NASA, has joined with NASA's Jet Propulsion Lab for a major role in Project Echo.

As director of this experimental project, NASA has invited independent researchers in communications, throughout the world, to engage in experiments of their own; NASA will assist interested experimenters by giving them tracking data.

**Payload**—Echo payload, developed by NASA's Langley Research Center, consists of an 82-gore plastic sphere 100 ft in diam. Material is 0.0005-in. Mylar polyester film covered with vapor-deposited aluminum. Before launch, sublimating powders are inserted in sphere: 10 lb of benzoic acid for initial expansion and 20 lb of anthraquinone for sustained inflation. The sphere is folded accordion-like

and packed into a 26½-in. diam magnesium container; both sphere and container are evacuated to decrease inflation rate at altitude.

Two wafer-like tracking beacons, 11 oz each, are attached to opposite sides of sphere equator. With a power output of about 10 mw, they transmit either on 107.97 or 107.94 mc depending on which of two payloads is used. Each beacon, about 10 in. in diam and ⅜-in. thick, has 70 solar cells and five nickel-cadmium batteries. A small whip antenna, coiled into a spiral groove in each beacon, springs out from side of sphere on inflation.

Satellite's internal pressure at altitude is estimated about 0.00004 lb/in.$^2$—at least 25,000 times the pressure due to solar radiation and air drag. How much these forces would influence the velocity and orbit at about 1000 miles altitude is of great interest to scientists. This can be done by comparing orbital data of the sphere with the third-stage casing of the Delta launch vehicle.

**Stations**—Primary stations taking part in this communications experiment are: Bell Telephone Labs' (BTL) facility at Holmdel, N. J., and the NASA JPL's Goldstone station, Calif. Radio signals are bounced between the East and West Coasts of the U. S. via the orbiting satellite.

Following establishment of accurate orbit by beacon, radar, and optical tracking, voice modulation transmission was accomplished using frequency modulation (FM) techniques.

BTL's transmission frequency is 960 mc/s for reception at Goldstone; JPL's is 2390 mc/s to BTL. Equipment at Goldstone includes two 85-ft-diam, paraboloid antennas—one a receiver and the other a transmitter. BTL transmitter is a 60-ft dish and receiver a special horn-reflector antenna. This antenna, which looks generally like the scoop of a steam shovel, is a recent development designed to cut down radio noise interference.

Communications equipment of both JPL and BTL have been exercised by bouncing signals between them via the moon and the Tiros I meteorological satellite.

Tracking activities are under the overall direction of NASA's Goddard Space Flight Center. An IBM 709 computer at NASA-Goddard Space Flight Center in Greenbelt, Md., aims radio antennas, on both coasts, at the satellite and indicates when to bounce signals.

**A Question Remains** — Echo sphere will be in continuous sunlight for about two weeks. After this, satellite's orbit and Earth's rotation around sun will bring the sphere in the Earth's shadow.

Sunlight plays an important part in maintaining sphere's shape. The sublimating powders turn into gas at temperatures slightly above freezing; out of sunlight, temperature of satellite will be well below freezing. In continuous sunlight the sphere's temperature will average about 239°F.

Once out of sunlight, gases keeping the satellite inflated will return to a solid state. Scientists are interested to learn if and in what form the satellite will reinflate when returning to sunlight. There is a question as to the amount of sublimating powders remaining after two weeks. Some will have seeped out through whatever punctures exist from micrometeorites. Unless the satellite returns to its spherical shape, it will not be useful for communications because of the non-uniformity of reflected signals from a misshapen surface.

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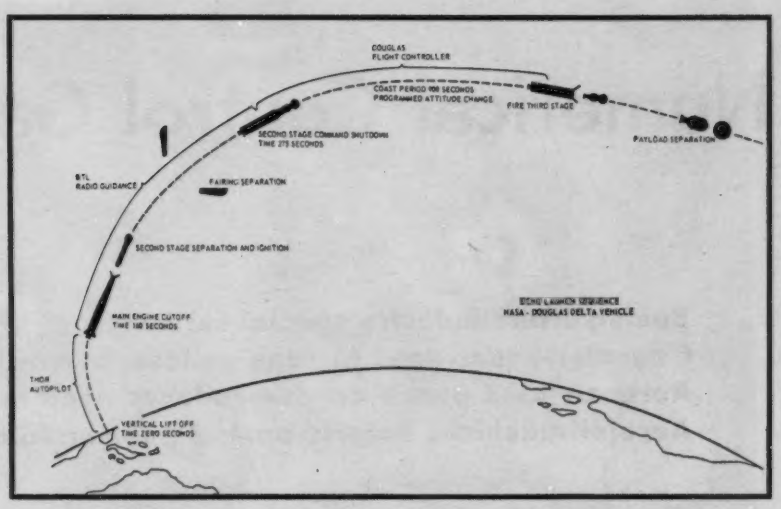


**DELTA VEHICLE** launch and orbit-injection phases shown.

## PROJECT ECHO MAJOR HARDWARE SOURCES

| | |
|---|---|
| **Satellite Film** | **DuPont (Mylar Polyester)** |
| **Satellite Sphere** | **G. T. Schjeldahl Co., General Mills (Devel.)** |
| **Sphere Aluminizing** | **National Metallizing Co.** |
| **Magnesium Container** | **Kaiser-Fleetwings** |
| **Tracking Beacons** | **Astro-Electronic Prod. Div., RCA** |
| **Delta Launch-Vehicle** | **Douglas Aircraft Co.** |
| **First-Stage Engine** | **Rocketdyne** |
| **Second-Stage Engine** | **Aerojet-General** |
| **Third-Stage Engine** | **Allegany Ballistics Lab.** |
| **Radio Guidance** | **Bell Telephone Labs. & Remington-Rand Univac** |

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# Numerical Control Gaining

**Boeing offers industry special services;**
**Chandler-Evans goes to tape philosophy—takes out guesswork;**
**Aeronca uses punch cards—reduces need for special tooling;**
**Aerojet machines Polaris parts to closer tolerances, cheaper**

**By S. Peter Kaprielyan**

Problem of survival in the aerospace industry has boiled down to the fundamental weapons of efficiency and economy. To implement these weapons, companies are exploring numerical-control production methods with mounting interest.

After six years of investigation, Boeing-Wichita boasts 21 numerically controlled machines of eight different types. Among these are: two types of profile mills—a Morey unit guided by magnetic tape (General Electric system) and three Kearny & Trecker profilers run by punched tape (Bendix system); three huge K & T skin mills, for the 80-ft wing skins of the B-52, controlled by magnetic tape; five Milwaukee-Matics (automatic tool changers); four Driv-Matic automatic riveters; one Pratt & Whitney three-spindle Keller profiler; two Jones & Lamson lathes; and two Pratt & Whitney jig borers.

"From this variety and depth of experience the company has found that numerical control offers high-quality, close tolerance results that surpass template methods in lead time, shop man-hours, and savings," states Robert C. Wilburn, Manager, Boeing Applied Computing Services.

Another new facet at Boeing is the use of two company-designed devices for verifying the tape—both its condition and the accuracy of its signals. One of these tests magnetic tape via oscilloscope, audio, and oscillograph. The other device is an electronic plotter-verifier. A stylus traces a full outline of the part "described" on the tape.

**Services Offered**—Other companies now seek Boeing's help and advice. Boeing formed a commercial service, known as BACS—the Boeing Applied Computing Services. The organization offers services in all phases of numerical control — machine programming of parts, tools dies and templates, and the complete preparation of tapes. BACS also provides consulting services, personnel training, tape verification, product design and all related programs in data processing.

"We have found that the greatest potential for eliminating decisions can be found in the tape-operated machine," says Thomas Linder, Jr., V.P. Manufacturing, at Chandler-Evans. "Since our most complex parts are housings that require the longest lead time, we have applied the tape philosophy to this area. Some housings run over 200 individual operations with some repeated 8 to 10 times per housing. Based on a one per cent human factor, no casting could be machined to completion without at least two dimensional errors. In addition, due to schedule pressures, there was always the danger of skipped operations."

First effort at Chandler-Evans toward tape control was to install black boxes on Potter & Johnston semi-automatic lathes. These controlled only the speeds and the feeds. As a result, the area of possible error was reduced appreciably. Another important application of tape control is used on Burgmaster turret drills. Now, one operator handles two machines.

In the prototype department, a Pratt & Whitney numerically-controlled jig borer eliminated hesitation between cuts. The operator no longer has to measure the last cut, compute the next location, position the tool and then recheck for accuracy. In a typical case, machining was reduced from 50 hr per piece to 32 hr.

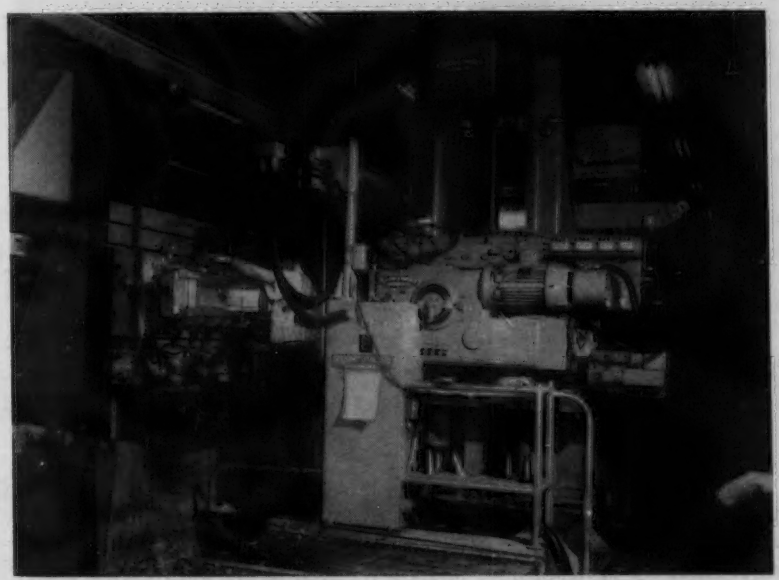
**Attractive Figures** — Possibly, the most spectacular benefits reaped from adopting numerical control, have resulted from the installation of a Kearney & Trecker Milwaukee-Matic. This machine accommodates one tool in its spindle and thirty more in its automatic revolving drum. By tape, it positions the material to be cut, searches out the correct tool for the cut and changes the tool in the spindle. This assures at least thirty-one continuous milling, drilling and boring operations with no manual handling of parts or tools, or changing of jigs or fixtures. Here are figures that dramatically illustrate the savings realized in the production of latest-type unitized fuel-control units:

Three main housings on this unit are the flange, the cover and the body. Set-up time on the cover was chopped from 21.1 to 6.0 hr. Cover tooling costs cut from $10,285 to $3445. Cycle time was shortened from 103.5 min. to 82.7. On the body, tooling costs were sliced from an estimated $17,830 to $5200 and cycle time from 247.6 min. to 104.5. Furthermore, to meet tough lead time schedule, 247 castings were machined on the Milwaukee-Matic in 14 days; 65 individual operations were performed on each casting for a total of 16,055 operations. Of this number, six were out of print dimension—all six were salvaged.

**Punched Cards Do It**—When a sudden design change required a shift from aluminum to steel hinges on the B-52-G wings, numerical control came to the rescue at Aeronca Manufacturing Corp., Middletown, Ohio. These hinges measure only 10 x 4 x 3 in., but are highly complex parts with thin webs, pockets with sloping bottoms, and many angles. A numerically-controlled Cincinnati Hydrotel is hogging them out of blocks of 4340 steel.

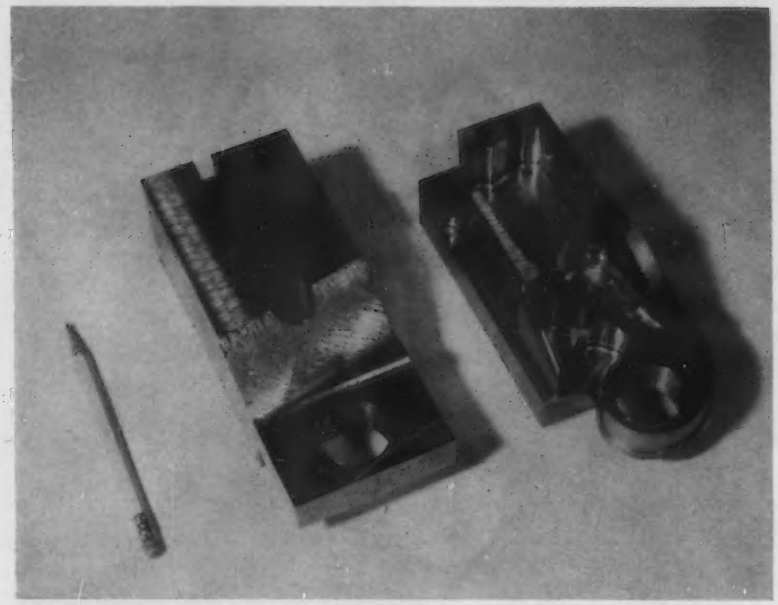
The entire machining sequence was worked out with the aid of a desk calculator and trig tables. The job was programmed for approximately 80 hr of programmer's time.

**TAPE-CONTROLLED** Pratt & Whitney jig borer, at Chandler-Evans, performs a succession of operations automatically, on main housing for Ceco fuel pump.

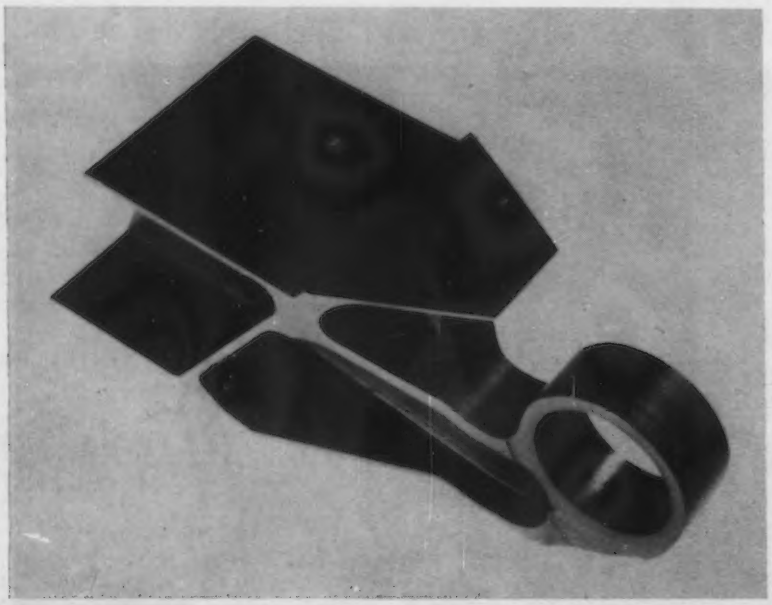


**NUMERICALLY-CONTROLLED** Kearney & Trecker profile mill is one of 21-machine complex used at Boeing-Wichita.

## Target-missile bulkheads profiled economically on vertical Hydrotel with three-axis contour control



**SPOILER HINGE for B-52-G** is shown in rough-machined form. Numerically-controlled Cincinnati Hydrotel, at Aeronca hogs such hinges out of 4340 steel.



**MACHINING TIME** of three hours is required to mill each spoiler hinge. Three cutter changes are required with a ¼ in. roughing end mill, and ⅜ in. finishing end mill.

It is set up on 1800 punched cards, arranged in two decks for roughing cuts and two decks for finishing cuts. The same cards are used for either hinge side, the numerical control circuitry making the necessary mirror image conversion.

It takes three hr of machine time with high speed tools to mill each hinge, including three cutter changes—a ¾ in. roughing end mill, and ⅜ in. and ¼ in. finishing end mills. A switch to carbide cutters will cut machining time to less than 1 hr per part.

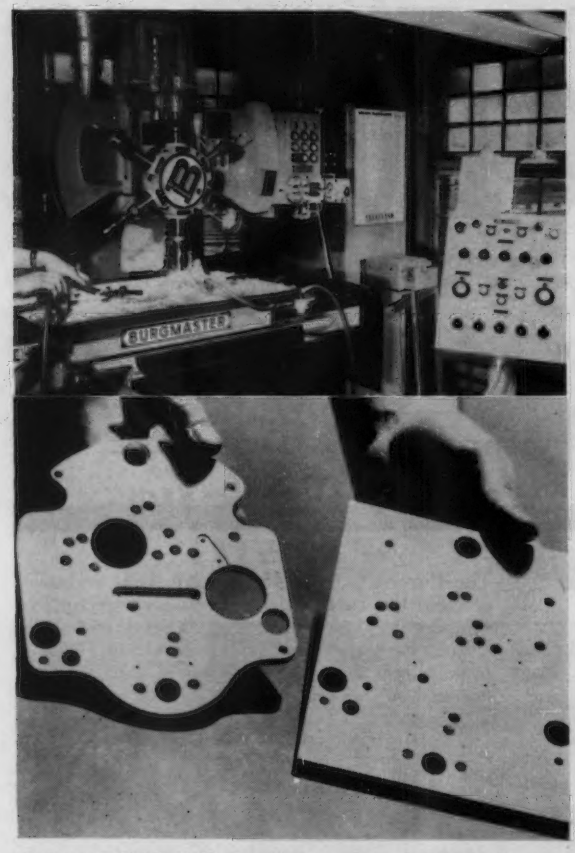
Aeronca is also faced with the challenge of producing a limited number of target missiles economically and still meet a tight production schedule. One of the problems encountered was the complex machining of a 7075-T-6 aluminum internal bulkhead. It has tapered sides and restricting radii at the corners and bottom surface.

The internal pockets are profiled on a Cincinnati 30 x 52-in. vertical Hydrotel equipped with Acramatic 3-axis contour control. Two machining operations complete the profiling. Roughing is done with a standard one-in. diam two-flute end mill to remove excess material and gain a flat bottom surface. Finishing cuts use a ½-in. diam, two-flute end mill ground with a 15 deg taper and 0.090 radius, to blend with the bottom surface. All dimensions are held to ±0.005 in., with a finish of 125 RMS.

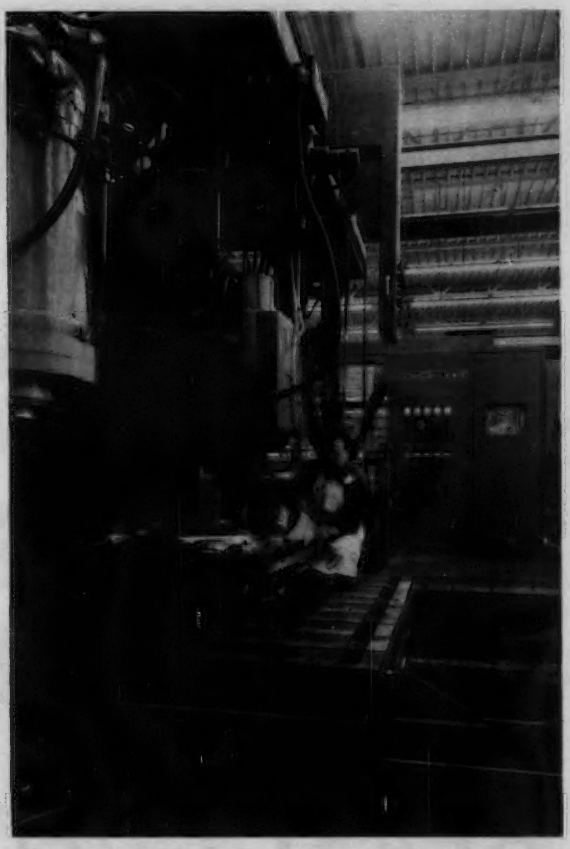
Tool path was plotted on a Friden desk calculator in a day. Card preparation and first part acceptance required two hours.

One very important cost reduction is noted. In the absence of tooling, standard clamps and locating bushings were used. Manufacturing lead time was reduced considerably.

Views expressed by Robert M. Russel, Supervisor, Tool Design, National Vulcanized Fibre Co.,




**HOLE DRILLING** in silicone-glass laminate by numerically controlled Burgmaster turret drill has upped quality and cut costs at National Vulcanized Fibre Co.



**POLARIS PART** production has been speeded up and tolerances have been tightened by using numerically controlled Giddings & Lewis 3-D miller at Aerojet.

concur with those of other numerical control users: "Taking the human element out of machining plastics alone means significant savings for us. The machine operator is not responsible for selecting the proper feeds and speeds. These are selected by a process engineer. Because optimum rates are preselected for each run, tool life is considerably extended."

A typical job at National was an aircraft computer part—a silicone-glass laminate bulkhead with 36 holes drilled from each side. Formerly, it required a drill jig which cost $160 and took a week to design and build. Ten different drills were required and it was not uncommon to find a hole missing in a completed part. Also, inaccurate positioning of the drill jig sometimes allowed smaller drills to veer off center and ruin the work. This operation is now done on the Burgmaster turret drill by numerical control; no drill jigs are needed and rejects are greatly reduced.

Another unsolicited testimonial on behalf of numerical control came recently from Aerojet-General, producing hardware for Polaris. Here, numerical control is used with a Giddings and Lewis three-dimensional, planer-type profile mill to make integral chamber heads and closures.

"Our results with numerical control have been even better than we had hoped," explained J. O. Brigleb, Manager, Inert Parts Manufacturing, Solid Rocket Plant. His summary of achievements through numerical control follow.

- Fabrication time of vital parts is shrunk by two-thirds.
- Production base is broadened, to the extent that several vendors can, through numerical control, furnish truly identical parts.
- Design changes are incorporated quickly, without affecting the basic tooling.
- Wall thickness of contours kept to ±0.002 in. has resulted in weight saving of 8 to 10 lb per part. Cumulative errors incurred previously through use of templates and models are now eliminated.
- Numerical control has proven out so well that the concept may soon be extended also to the manufacture of Polaris inert hardware.

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# Work-Horse of The Satellites

**Discoverer XIII successful orbit and re-entry capsule recovery establishes feasibility of space-capsule delivery from orbiting vehicles; Purpose of overall program is to test spectrum of basic satellite functions**

By Philip Geddes

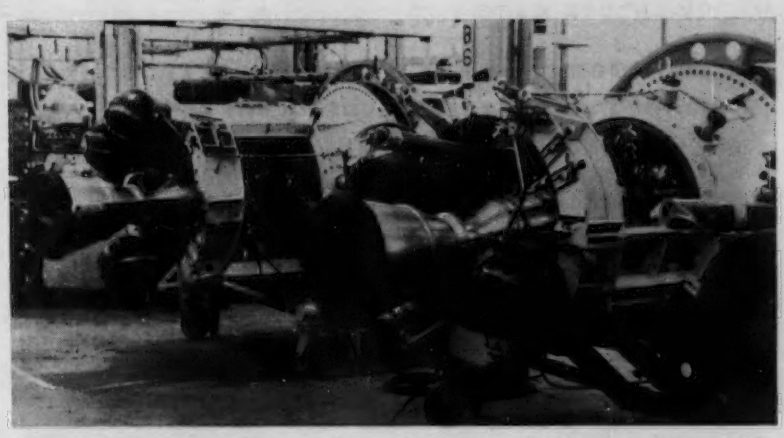
**DISCOVERER/AGENA** launchings take place from one of two modified Thor IRBM training sites at Vandenberg Air Force Base. Here the Agena satellite vehicle and its Thor booster are being erected into launch position.

**On August 11, fishing of Discoverer XIII capsule from target area northwest of Hawaii marked a turning point for this program. This event bolstered Air Force's earlier contention that recovery techniques should not have been blamed for the failures originating before the de-orbit phase.**

First Discoverer space vehicle was orbited on February 28, 1960; twelve more firings in the series have followed. Most widely publicized aspect of Discoverers has been the failure to recover the second stage—Agena's payload from orbit. What has been accomplished by the thirteen launches?

Discoverer program is an "open end" R&D effort originally planned

for a small number of shots. Objective was to derive a design base for later military satellites, namely Midas and Samos. "Payload reentry and recovery were secondary objectives, not ends in themselves. The value of Agena vehicles has been proved." That statement represents both Lockheed's and the Air Force's outlook on the subject of recovering capsules. Unfortunately, in the popular view such remarks are open to suspicion as cover for costly failures. On several occasions, claiming success in failure has had a hollow ring, yet there has been considerable achievement in Discoverer series.



**AGENA SATELLITES** are shown going through final modification and checkout at the Lockheed Missile and Space Division's facility at Vandenberg Air Force Base.

**Agena Into Orbit** — Thor has proved a reliable booster. (Table I.) But Thor is not the most desirable first stage for launching satellites by virtue of its restricted payload capacity.

Agena vehicle, used as the orbiting second stage in Discoverer, was intended originally for Atlas boosters equipped with full radio-inertial guidance systems. Thors were available for experimental work-horse use with proven reliability—Atlases were not. A decision was made to use modified Thors for orbiting Discoverer vehicles. Midas and Samos systems could not be carried on a Thor orbited Agena, but at least the basic Agena could be injected into orbit even if lower than intended for the reconnaissance satellites. Thus, the basic vehicle could be debugged and experience gained. For the Discoverer program, in the interest of weight saving, the normal Thor guidance system was reduced. Thor booster follows a tape-programed ascent trajectory using only the autopilot for attitude stabilization. Weight capacity is made up again on the Thor by allowing booster fuel to burn to near exhaustion, instead of cutting off thrust at a required velocity.

### Orbit-Injection Phases

(1) Thor boosts Agena along pre-programed trajectory — apogee equal to required injection altitude; azimuth determined by required orbital plane. At Thor thrust termination, Agena separates from booster. Discoverers are fired into a roughly polar orbit from Vandenburg.

(2) In coast phase, after separation from Thor, Agena horizon scanner and inertial system signals turn vehicle to local horizon and keep it there. This is much more difficult than fixed stabilization in space, as in deep-space satellites.

(3) Tracking information is computed from Thor performance. Based on this, the required Agena velocity increment is determined, and ignition instructions transmitted. Correct injection velocity into orbit is achieved by the Agena, at the Thor booster apogee height. This injection point is then the perigee of the satellite orbit (average 121 miles for the series).

**Precision Needed**—Utmost precision is required in velocity and flight path at injection into orbit; this is because relatively low altitudes are involved in Discoverer program. No other satellite program has attempted to deliberately achieve such low orbits with maximum payload. Despite handicaps in booster guidance and weight limitations, seven Agenas have achieved orbital velocity out of possible ten. Thor success can be measured in ten out of twelve firings. At an altitude of 120 miles, an angle error of −1.1 deg or velocity margin lower than 100 ft/sec below circular orbit figure, will result in failure to complete first orbit. With an injection velocity of about 25,000 ft/sec, 100 ft/sec error represents roughly 0.4 per cent.

Agena guidance system can control injection angle to much less than the limits shown in Table I. It should be noted that the 2½ deg error on Discoverer I would have caused failure if perigee had not been higher than on subsequent shots. Discoverer I did not use a horizon scanner.

**Agena Systems**—Engine is made by Bell Aircraft, designed as power source for B-58 Hustler pod. Delivers 15,000-lb thrust for 120 sec. Early version used JP-4 and red fuming nitric acid, later changed to UDMH giving improved specific impulse. Agena B under development will have larger tanks, higher performance engine with restart capability. Engine has never failed to start on command.

Stabilization to the local vertical during phase (2) of injection and orbit is made by reference signals from an inertial reference package with a coupled infra-red horizon scanner. Command signals are also transmitted from the ground. System combines position signals from three orthogonal position gyros with rate information from three orthogonally mounted rate gyros. Force to change vehicle attitude in pitch and

## Orbit prediction made from initial radar track modified by data from subsequent passes

yaw during powered flight, comes from swivelling the main engine nozzle by means of two hydraulic servos. During coast and orbit, error signals from the stabilization controls activate cold gas reaction jets on the side of the Agena. Dry nitrogen gas ($N_2$) mixed with tetrafluoromethane ($CF_4$), stored at high pressure in titanium spheres, does the job. As the cold gas system is not designed to overcome Agena engine asymmetry, it is locked out during powered flight.

During guidance into orbit and subsequent orbit, tape - programed signals torque the position gyros in intertial reference package to correct errors in injection trajectory. Compensation for the continuous change in orientation in space to maintain fixed reference to the local vertical is obtained by continuously torquing-in about 4 deg per minute. Since the 4 deg rate is only an approximation of the actual required pitch rate, additional compensation must be provided, plus compensation for gyro drift in the inertial reference package. This compensation is provided by the infra-red horizon scanner. Probable drift rates and errors in Discoverer are held down to approximately 1 deg in pitch, 0.5 deg in roll, and 1.5 deg in yaw.

Stabilization system for the Discoverers orbited, has worked remarkably well. In five Discoverers the system worked as called on, on five others failure lay outside the stabilization system. On two others there was a tenuous link between this system and failure. On discoverer VII an auxiliary power supply defect upset the IR scanner and prevented stabilization on orbit. Discoverer VIII Agena engine did not shut off as planned. The satellite went into a highly elliptical orbit causing the stabilization gas supply to become exhausted.

Midas and Samos can only perform properly if the satellite is a steady platform. No U. S. satellite earlier than the Discoverers was fully stabilized. At best, primitive stabilization only was achieved through spin rockets.

**Lessons Learned** — Agena vehicle moves in a low orbit. Prediction of orbit is made from the initial firing radar track and modified by data from later passes. Some idea of the precise position reporting achieved with Discoverers can be shown by reference to No. XI. After the first pass, predictions could be made of time of arrival at subsequent check points within one sec. Capsule recovery signal on, seventeenth pass, was given within five sec of the planned time after a total orbiting time of about 27 hr. For the capsule, five sec error means nearly a 25-mile distance error from the planned recovery point. Prediction of low-altitude orbits is complicated by the simple spherical Earth-motion and the oblateness of the Earth, plus oblateness of the satellite's orbit complicated by orbital decay through drag.

Midas and Samos, as with most applications of Agena vehicles do not require re-entry provisions. However, on all Discoverer satellites after No. I, recovery was an objective. From Table I we see that capsule separation was only possible in the first place from six Agenas. Separation was successful on five of these attempts. Failure came later down the sequence. The separation and reentry phase begins when a timing device on the vehicle, on about the seventeenth pass over the Earth, starts the following actions:

(1) Whole Agena vehicle pitched to 60 deg from horizontal, by gas jets.

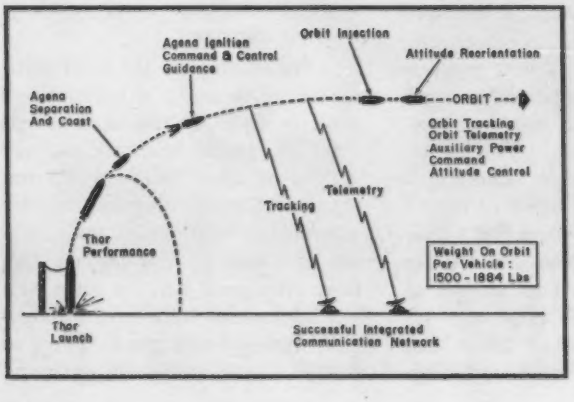
(2) Separation of capsule from Agena occurs through explosive bolts and springs.

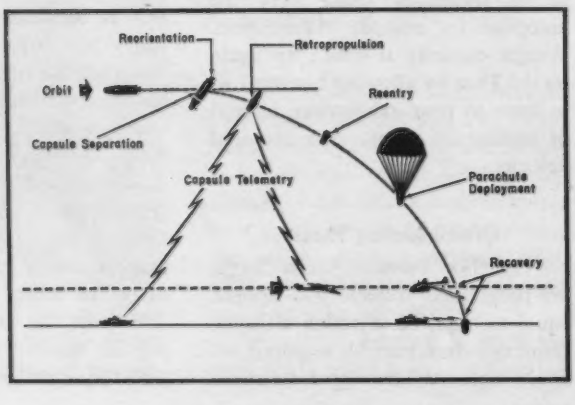
(3) Retrorockets in re-entry vehicle slow it down to the correct velocity for the trajectory back into Earth's atmosphere.

(4) At proper altitude "g" switch operates to open parachute and release spotting chaff for easier radar detection.

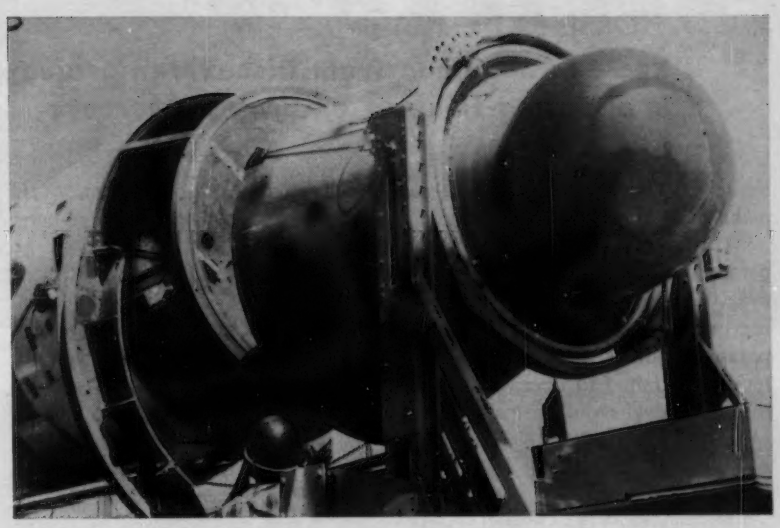
(5) Recovery planes air snatch target. Ships home on marker beacon if capsule lands at sea.

## DISCOVERER SATELLITE PHASES—LAUNCH THROUGH RECOVERY



**Recovery problems**—Assuming reasonable orbit, problems start with the timing cycle. Every second of timing error means five miles error at pickup point. The narrow recovery band can easily be missed. Recovery glide angle followed is critical at approximately 3½ to 1½ deg. If angle is too steep, vehicle decelerates too rapidly and is subject to higher heat rates than desired, even if for a shorter interval. If angle is too shallow the dispersion of impact points is spread out. Under these circumstances, capsule is much more difficult to find. A compromise has to be worked out between these two, cost dictating the extent of the latter search operation. The greatest problem then, is the critical vehicle alignment and retro-thrust application to achieve 3¼ deg at the right time. Five Discoverer capsules have separated from the Agenas. Three capsules, V, VIII, and XI have been tracked after separation. Capsule VIII and XI telemetering data shows proper functioning of critical components. On all three the retro impulse was applied but not accurately enough for re-entry into the recovery area.



**RE-ENTRY VEHICLE** is being mated to Agena's main structure. Separation is effected by a series of springs and explosive bolts actuated by a timing device. Ground controllers adjust timing device by radio command while satellite is on orbit.

### Summary of Defects

**Discoverer I** was not intended to go all the way after orbit and can be regarded as a first step in proving basic feasibility, of Thor/Agena combination.

**Discoverer II.** Orbited. Timer in vehicle was set incorrectly, there was no component failure but capsule released in wrong place. Capsule reported landing in Spitzbergen.

**Discoverer III & IV.** No orbits. System error in which "a two-ton truck was trying to carry a five ton load" orbital speed too low to achieve orbit. Margin of velocity error large in III but very slight in IV.

**Discoverer V.** Orbited. Capsule temperature in flight fell to about 24 deg F on the fifteenth orbit after which capsule was ejected. Temperature was too low for operation of batteries at full power. Result was component failure — V is

**NOSE-CONE AFTERBODY** is being fitted with its instrument wiring harness prior to installation on cone.

## Know-how gained from Discoverer project is directing thinking on Project Mercury

thought to be the mystery satellite picked up on radar six months later.

**Discoverer VI.** Orbited. Temperature problem in V was thought overcome in VI by changing coating on the capsule. In orbit temperature showed small rise but batteries still failed to operate to performance level required. Later birds were fixed by installing a thermostat-controlled heater to hold temperature to 80 deg F.

**Discoverer VII.** Orbited. Serious component failure in Agena auxiliary power supply. The 400 cycle current to IR scanner and separation mechanism cut off. This was first Agena component failure.

**Discoverer VIII.** Highly elliptical orbit resulted, and altitude control gas exhaustion followed.

**Discoverer IX & X.** No orbits, due to Thor booster component failures. Discoverer IX Agena also failed to perform as required.

**Discoverer XI.** Orbited. Agena component failure at re-entry (unknown) causing improper re-entry trajectory.

**Discoverer XII.** No orbit. Serious problem in Agena attitude control system. Cause has been isolated. Electrical problem experienced for the first time unrelated to a component failure.

**Analysis**—After Discoverer VI recovery failed, a detailed analysis of recovery systems was undertaken. The design was reviewed by people outside the project and components were tested. Some "possible contributing causes" were found and fixed, but the essential design remained unchanged.

A similar review was undertaken after Discoverer XI. Since recovery could no longer be held a secondary objective, an attempt was made in XII to bring back all the data essential to separation and recovery.

A serious attempt was made to tighten the air/sea recovery system. More ships and planes were deployed; the number of tracking stations increased. The first C-130 test-recovery plane was inserted into the program. C-130's will eventually replace or supplement C-119's used at present.

Discoverer XII carried a "diagnostic payload" which was going to give all the answers. Discoverer XII never made it into orbit—much to the disappointment of everyone close to the project. Objective analysis of the whole Discoverer program shows the record is good even if some publicity aspects are not. The series achieved the major purpose of learning how to put hardware into orbit. The information on Agena performance has upped the learning curve for this type vehicle a long way—the success of Tiros being some indication of this. Project Mercury also has benefited.

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## TABLE I. PERFORMANCE AND ORBITAL PARAMETERS OF DISCOVERER SATELLITES

| Number | Date | Launch | Staging and Ignition | Command Computing | Orbital Velocity Attained | Stab. and Commd. on Orbit | Perigee Stat. Miles | Apogee Stat. Miles | Capsule Separation | Recovery | Tracking Communications and Telemetry | Inject. Alt. Stat. Miles | Inject Angle Degrees Up | Eccentricity Nominal | Eccentricity Actual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 2/28/59 | S | S | S | S | NA | 99 | 605 | NA | n/a | F | 183 | −2.5 | 0.03 | 0.059 |
| II | 4/13/59 | S | S | S | S | S | 142 | 220 | S | S(1) | S | 158 | +0.2 | 0.01 | 0.007 |
| III | 6/3/59 | S | S | S | F | n/a | n/a | n/a | n/a | n/a | S(2) | 165 | −0.22 | * | * |
| IV | 6/25/59 | S | S | S | F | n/a | n/a | n/a | n/a | n/a | S(2) | 103 | +0.1 | * | * |
| V | 8/13/59 | S | S | S | S | S | 136 | 450 | S | F(3) | S | 138 | +0.01 | 0.05 | 0.041 |
| VI | 8/19/59 | S | S | S | S | S | 138 | 537 | S | F(2) | S | 139 | +0.4 | 0.05 | 0.047 |
| VII | 11/7/59 | S | S | S | S | F(4) | 104 | 550 | F(4) | F(4) | S | 120 | −0.34 | 0.05 | 0.049 |
| VIII | 11/20/59 | S | S | S | S | S | 120 | 1000 | S | F(5) | S | 120 | −0.04 | 0.05 | 0.102 |
| IX | 2/4/60 | S | S | S | F(6) | n/a | n/a | n/a | n/a | n/a | F(6) | ** | ** | ** | ** |
| X | 2/19/60 | S(7) | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | F(7) | ** | ** | ** | ** |
| XI | 4/15/60 | S | S | S | S | S | 109 | 380 | S | F(8) | F(8) | 106 | −0.16 | 0.04 | 0.032 |
| XII | 6/29/60 | S | S | S | F(9) | n/a | n/a | n/a | n/a | n/a | ? | | | | |

**LEGEND:**

NA—no attempt, *—orbit not achieved due to low velocity, **—orbit not achieved due to booster malfunction, S—successful, F—failure, n/a—not applicable due to earlier failure in sequence of events.

**NOTES:**

(1) Re-entered. Parachute deployment accomplished over Spitzbergen. No air snatch possible.

(2) Communications, tracking and data acquisition were solid thru launch, coast and injection phase.

(3) No radio signals were received from recovery beacon. No visual sightings.

(4) Failure of an inverter which provided power for the IR scanner and the separation sequence prevented full stabilization on orbit and proper separation of the capsule.

(5) Positive indications of retro-rocket firing; capsule re-entry; and beacon operation prior to parachute deployment. Action of stabilization system to react to highly elliptical orbit caused premature exhaustion of gas. Improper satellite attitude at time of capsule separation caused the re-entry vehicle to over shoot the recovery area by several hundred miles.

(6) Initial velocity insufficient to achieve orbit—Thor defect. Acquisition and tracking on launch satisfactory.

(7) Vehicle destroyed by range safety officer 56 sec after lift off. Flight control electronics source of trouble.

(8) Unknown action disturbed capsule immediately after separation caused improper trajectory during retro-rocket fire.

(9) Defect in attitude control system. Electrical problem outside of component failure.



Circle 7 on Inquiry Card——→

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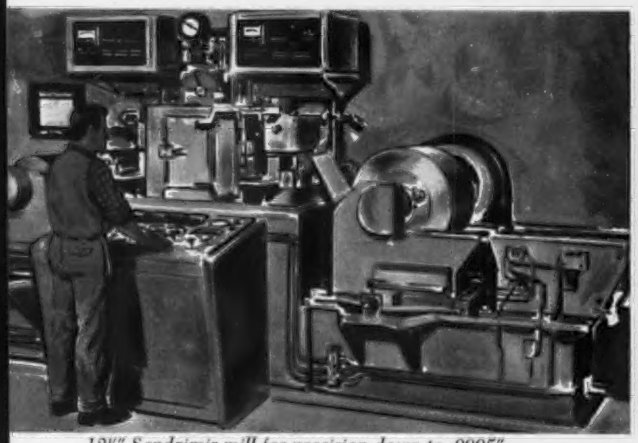

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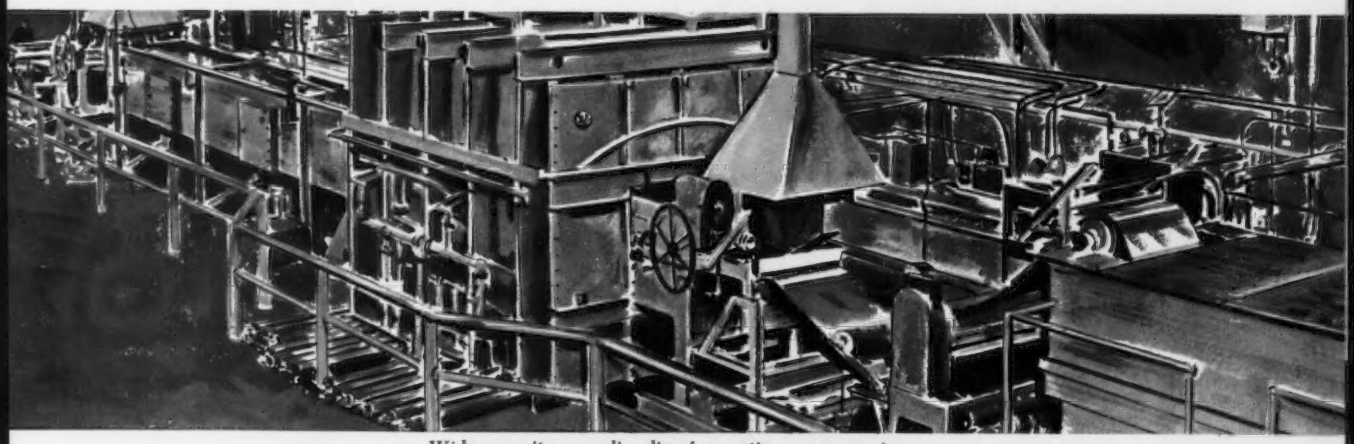

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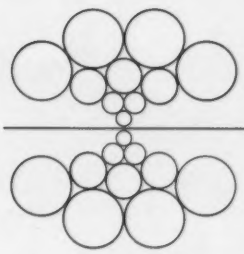

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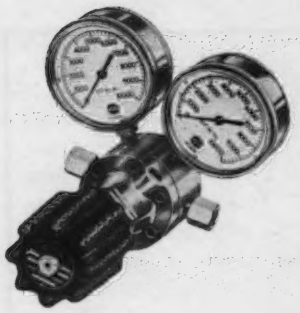

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Bulletin R19

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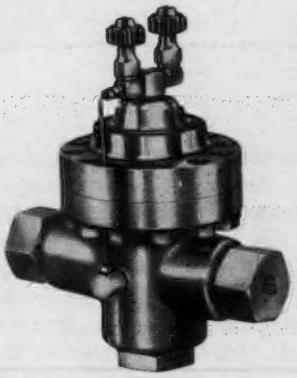
Low torque: 35 inch-lb. at 7,000 psig.
60 inch-lb. at 10,000 psig.
Panel mounting
Bulletins R11 and R17



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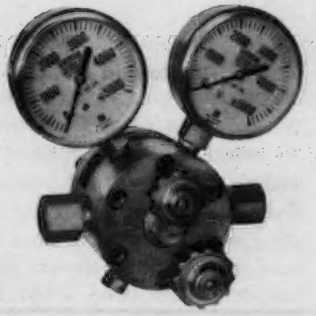

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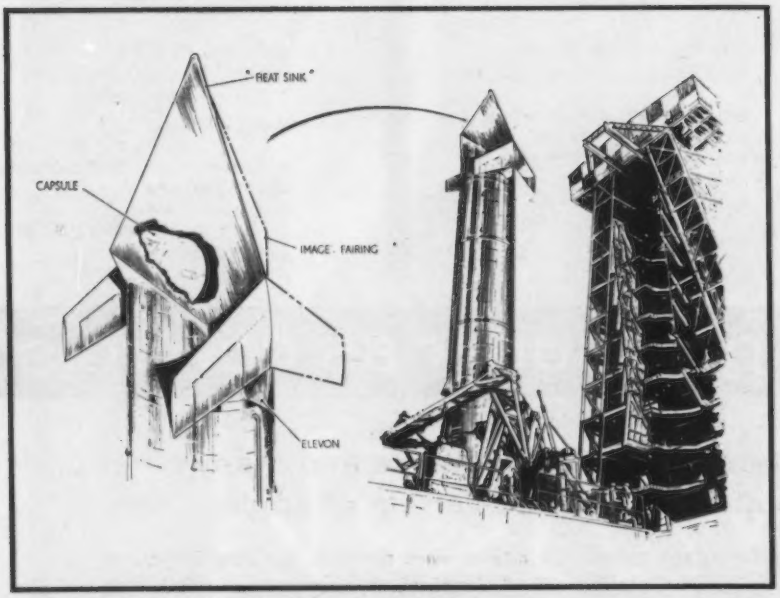
# Dart-Shaped Satellite

**Concept advanced by Armstrong Whitworth Aircraft strikes compromise between large, heat-dissipating shape and dictates of compactness to reduce launching complexity**

**By Ronald A. Cole**

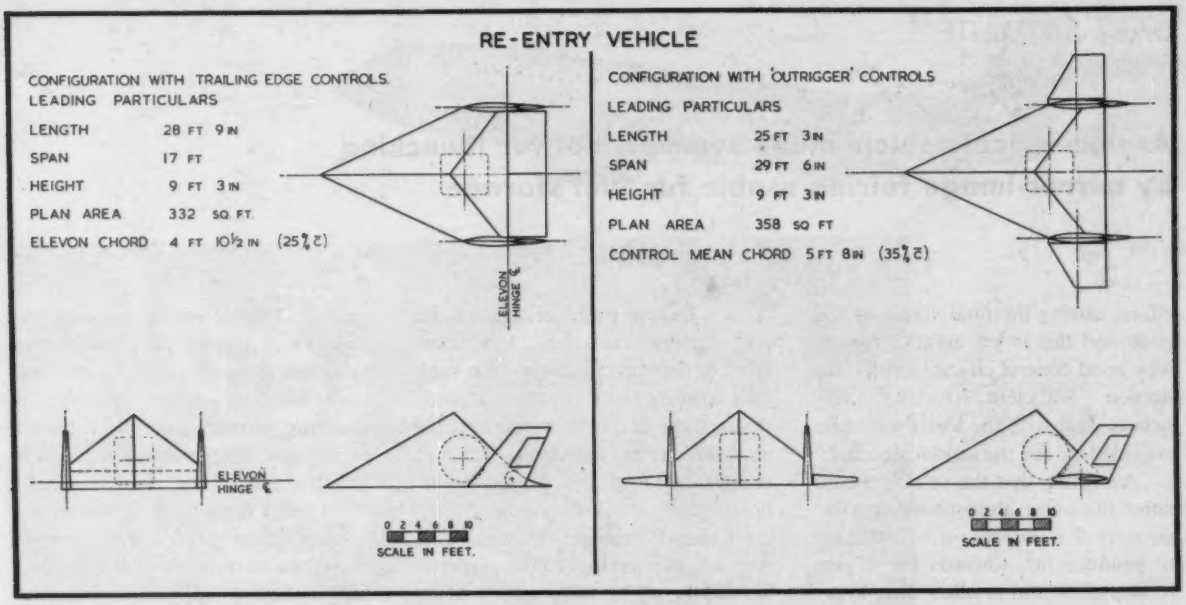



**SATELLITE AND LAUNCH VEHICLE** proposed by Armstrong Whitworth uses "dart shape" and British booster. Lift producing reentry vehicle would have wing area of 322 sq ft, weight of 4120 lb. Elevon controls seen as effective up to speed of Mach 25. Crew survival planned for arctic, jungle, and water landings.

Some novel ideas on the design of manned satellites have been put forward by Armstrong Whitworth Aircraft, England. Most of this thinking results from concentrated study of heat dissipation problems during re-entry; but, other problems such as launching have not been lost sight of, and this has lead to the consideration of compactness.

Since the vehicle is intended to break orbit and descend using aerodynamic lift, the lowest possible wing loading has been adopted. This is a major requirement to keep heating to a minimum. Another is that most of the heat generated due to drag goes into the wake and not into the vehicle. To reduce heat concentration, a large wing span would be desirable, however, this does not lend itself to integration with the carrier rocket and a compromise was reached.

**Using Induced Drag**—A large working incidence and low lift/drag ratio is desirable because induced


RE-ENTRY VEHICLE
CONFIGURATION WITH TRAILING EDGE CONTROLS
LEADING PARTICULARS
LENGTH 28 FT 9 IN
SPAN 17 FT
HEIGHT 9 FT 3 IN
PLAN AREA 332 SQ FT
ELEVON CHORD 4 FT 10½ IN (25% ℄)
ELEVON HINGE ℄
ELEVON HINGE ℄
0 2 4 6 8 10
SCALE IN FEET.
CONFIGURATION WITH 'OUTRIGGER' CONTROLS
LEADING PARTICULARS
LENGTH 25 FT 3 IN
SPAN 29 FT 6 IN
HEIGHT 9 FT 3 IN
PLAN AREA 358 SQ FT
CONTROL MEAN CHORD 5 FT 8 IN (35% ℄)
0 2 4 6 8 10
SCALE IN FEET.

drag is a powerful brake and does not inevitably produce body heating. Under certain conditions of flight and in maintaining orbit pattern this lift may be a nuisance. Since it is not possible to eliminate it entirely and still enjoy the effects of induced drag, some method of reducing it had to be found. This may be accomplished by rolling first one way and then the other, so as to give the vehicle a sinusoidal path about a mean track.

On the basis of these requirements the vehicle needs to be stable in both subsonic and supersonic flight. It must be capable of being trimmed at large angles of incidence and have a good measure of aerodynamic control in both pitch and roll. In fact these control parameters led to the abandonment of Dr. Hilton's earlier circular planform concept and adoption of the delta shape.

Other advantages follow from using the delta plan and among these is the important one of crew psychology. The fact that they will have some control over the vehicle and consequently their destiny, will improve their outlook and thinking. To cope with experiments, piloting, and communication, a two-man crew seems necessary. The crew capsule would be situated in a region of very high vacuum. This is done by positioning it behind the leading edge shock wave and near to or on the low-pressure surface of the vehicle. The underside, or pressure surface, would be designed for heat erosion and possibly have a thick layer of insulant.

Rectangular and delta planforms of different proportions were investigated to find the optimum design. Eventually a rather narrow delta shape was adopted along with a tetrahedron-like body. This type of structure offers the advantage of lightness, ease of construction and sufficient internal volume. Tip fins and rudders are sufficient for control at low speeds and the large area elevon at the trailing edge is one suggested means of pitch control. Low-speed wind tunnel tests on models of this general design have proved the validity of this concept.

A proposal for a space sled of tetrahedral shape was originally made by Nonweiler of Queen's University, Belfast, in 1958. Then it was suggested that the lower surface of the vehicle be shaped like an inverted "V" or "W". Shock waves would stretch across the apexes and insulate the main surface from frictional heating. Each apex would be of heavy construction to withstand erosion and could in effect be likened to sled runners.

Because the whole upper surface would be riding in a high vacuum it would remain cool. The crew within their capsule and inside the skin would enjoy good insulation and protection. By sealing the front end of the pyramid and venting the interior through the rear wall, very low internal pressures and still better insulation from the lower surface would be obtained.

**Design Considerations**—As envisaged by Armstrong Whitworth the "dart satellite" would have a wing area of 322 sq ft. Present day delta wings which have a low thickness/chord ratio weigh between 5 and 7 lb/sq ft. Although a much larger t/c ratio will be used, the need for heat protection will add further to the structural weight. In fact, it seems unlikely that 5 lb/sq ft could be bettered. Accordingly, weight breakdown would be as follows: wing, 1660 lb; fins, 140 lb; capsule with crew and instruments, 2000 lb; retro-rockets, fuel and tanks, 200 lb; and controls with actuators and power supplies, 120 lb. The total of 4120 lb gives a loading of 12.4 lb/sq ft. Such a low loading will give rise to severe gust

## Asymmetrical vehicle made symmetrical for launching by mirror-image fairing usable for fuel storage

effects during the final stages of the glide and this is yet another reason why good control characteristics are needed. Sufficient structural stiffness to deal with the loads would be provided by the pyramidal structure.

Assuming that the vehicle would enter the outer atmosphere at a little over 5 miles/sec, it would have to produce lift, towards the Earth, to skip-glide and to allow drag braking. A typical case of re-entry at a height of 65 miles has been studied. Taking into account the effects of skin friction it is estimated that deceleration would be 1.2 ft/sec/sec and a heat equivalent to 18.3 kilowatts/sq ft would be generated. Possibly, 5 or 6 per cent of this will go into the structure—say 1 kilowatt/sq ft. This is not exceptional but higher inputs of about 6 kw/sq ft may be expected at lower altitude.

As far as the pressure surface is concerned this latter figure represents a major problem and so far no detailed solution has been offered. However, venting the vehicle's interior through the rear wall, where there is a high vacuum, could insulate the capsule from the high temperatures of the pressure surface.

**Control Problem**—Elevon control would seemingly give response across the flight range from Mach 25 but its characteristics are not ideal from the handling point of view. For instance, its upper surface is ineffective because it is situated in a vacuum. Therefore, its function is to reduce the chord of the lower surface when deflected up and cause a change of the center of pressure. Better means of control would be provided by small outrigger surfaces in the horizontal plane but this is not a compact arrangement. A final selection on the type of control will have to be made after more extensive wind-tunnel investigation. During initial re-entry the stability of the satellite would bear little resemblance to that of an aircraft because of the absence of damping terms. In fact, it would experience a continuous oscillation in pitch and roll.

Tunnel tests have shown that a lift coefficient of 0.7 and possibly more can be achieved. If a landing lift coefficient of 0.6 is assumed, then for a wing loading of 12 lb/sq ft the touch-down speed would be 88 ml/hr. In view of this, it is thought that the complete capsule should be jettisoned and reliance made on a parachute descent. Since the capsule is airtight it would also be water tight and could be made to float in a desired attitude. Also, in the event of landing in an arctic area, it would provide living accommodation until the crew was rescued.

Although the general shape of the satellite seems satisfactory in all aspects of the flight, it presents an awkward launching problem. Since it is not symmetrical it would have a strong effect on initial performance if mounted on a rocket's nose. This trouble has been overcome, at least theoretically, by the use of a mirror-image fairing. The actual satellite would occupy one half of the rocket's nose and the lightweight fairing the other. To give symmetry of weight and inertia it would be possible to use the dummy for fuel storage.

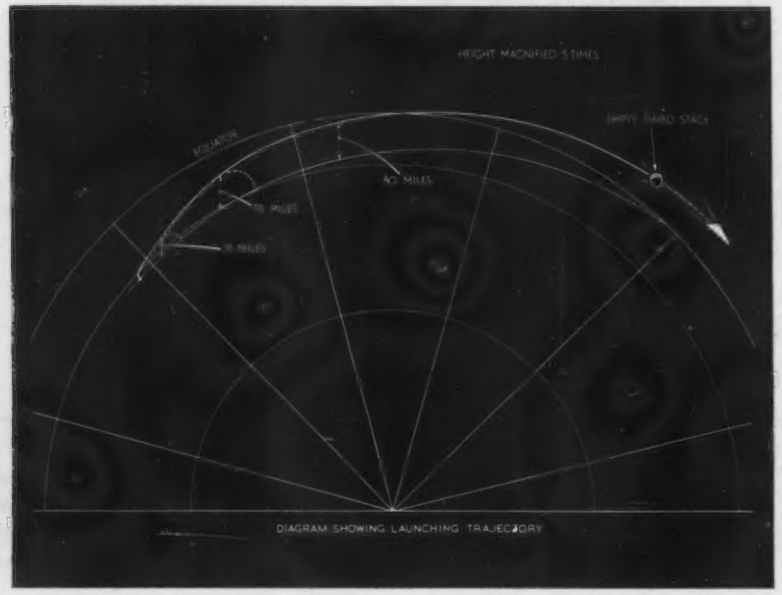


DIAGRAM SHOWING LAUNCHING TRAJECTORY

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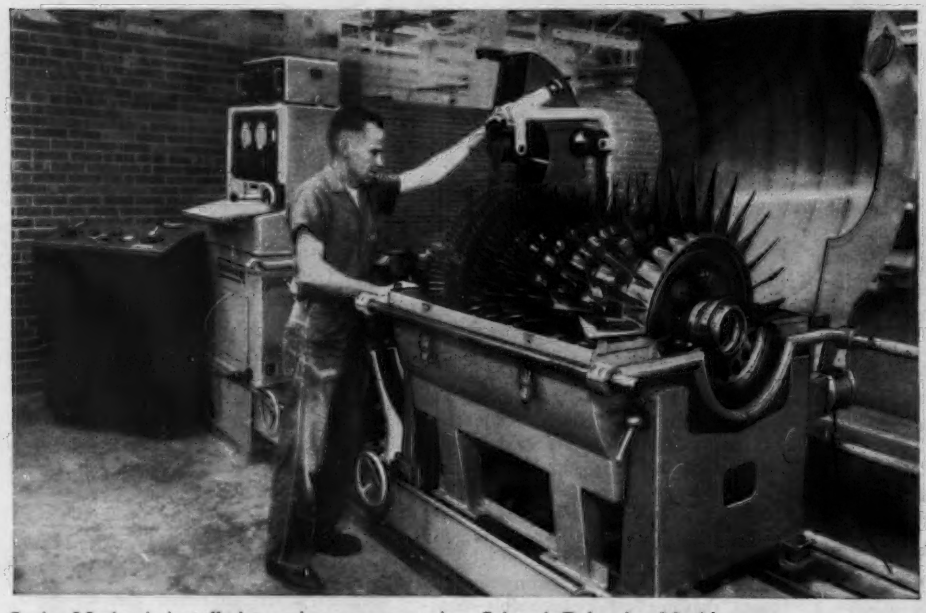

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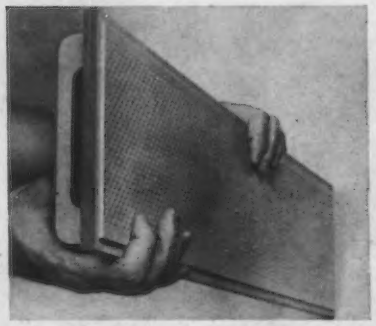
*Important facts to know about Laminated Plastics*

# LAMINATED PLASTICS *What they are, where they can be used*

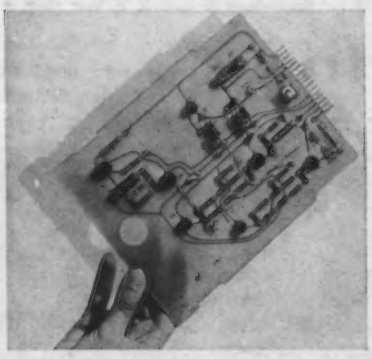
Taylor laminated plastics, also known as reinforced plastics, are thermosetting-type materials formed by impregnating paper, cotton cloth, asbestos, glass cloth, nylon or other base materials with synthetic resins and fusing them into sheets, rods, tubes and special shapes under heat and pressure. These materials exhibit a valuable combination of characteristics, including high electrical insulation resistance, structural strength, strength-to-weight ratio, and resistance to chemical reaction; also adaptability to fabricating operations.

**Types of laminated plastics made by Taylor**
There are four basic types of Taylor laminated plastics commonly specified and used throughout industry today. They are as follows:

**Phenolic Laminates.** Paper, cotton fabric or mat, asbestos, glass cloth or nylon bases impregnated with phenol formaldehyde resins. These provide strength and rigidity, dimensional stability, resistance to heat, chemical resistance, and good dielectric characteristics. Some Taylor grades are excellent basic materials for gears, cams, pinions, bearings and other mechanical applications. Others are widely used in terminal boards, switchgear, circuit breakers, switches, electrical appliances and motors. Also in radios, television equipment and other electronic devices; and in missiles as nose cones, exhaust nozzles, and combustion chamber liners.

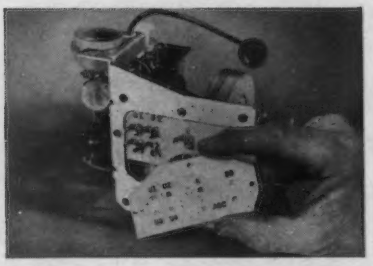


**Melamine Laminates.** Glass cloth or cotton fabric impregnated with melamine formaldehyde resin. Taylor melamine laminates have superior mechanical strength and are especially desirable for their arc-resistant qualities. Good flame and heat resistance, good resistance to the corrosive effects of alkalis and most other common solvents, besides other favorable characteristics. Typical applications include arc barriers, switchboard panels, and circuit-breaker parts in electrical installations.



**Silicone Laminates.** Continuous-filament woven glass fabric impregnated with a silicone resin. These laminates combine high heat resistance (up to 500°F. continuous) with excellent electrical and mechanical properties. They are primarily used in high-temperature electrical applications and high-frequency radio equipment.

**Epoxy Laminates.** Continuous-filament woven glass fabric or paper impregnated with epoxy resin. Glass-fabric grades are designed for use in applications requiring high humidity-resistance, good chemical resistance,



and strength retention at elevated temperatures. Paper grades are used under high-humidity conditions where resistance to acids and alkalis is required. Both grades are characterized by good dielectric strength, low dielectric losses, and high insulation resistance even following severe humidity conditions.

• • •

Recent technical advances in the bonding of various metallic and nonmetallic materials to laminated plastics have opened up new design opportunities. It is now possible to bond virtually any compatible material with a laminated plastic to form a composite which combines the advantages of both. One of the first composite materials was a copper-clad laminate used for printed circuits. More recent composite laminates, usually manufactured to customer specification, include the following: Taylorite® vulcanized fibre-clad, rubber-clad, asbestos-clad, aluminum-clad, beryllium-copper-clad, stainless-steel-clad, magnesium-clad, and silver- and gold-clad. Any one of these materials can be sandwiched between sheets of laminates, too, and can be molded to fit specific requirements.

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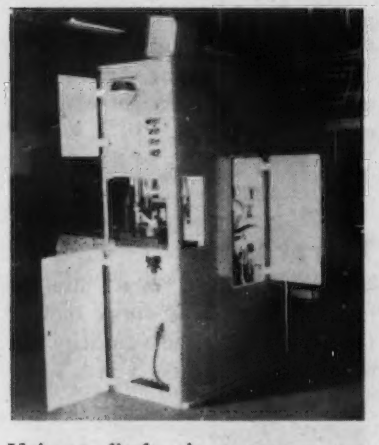
# New for Production

*Products at The Machine Tool Exposition—1960*

## Multi-Compaction Press

Automatic hydraulic press is designed for compaction of powdered metals, glass and plastics.



Unit on display is a one-ton, top and bottom ram press tooled for volume production of tantalum capacitor anodes. Tooling modifications make it adaptable to a variety of powdered metal compaction operations, including ferrous, nonferrous and the so-called "exotic" metals.—Denison Engineering Div., American Brake Shoe Co. Booth 914.

Circle 55 on postcard for more data

## Drill Pointer

Model "600" drill pointer features the Oliver point with increased clearance at the center of the drill. Has a ½ in. to 3 in. capacity. Can grind two, three and four flute drills. Has provisions for variable clearance and variable included point angles. All cutting lips of drill are ground in one continuous motion.—Oliver Instrument Co. Booth 342.

Circle 56 on postcard for more data

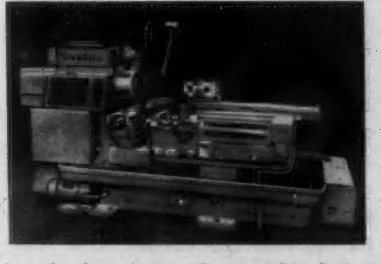
## Fast Grinding

The CM-2 Multiwheel Grinder is designed for plunge grinding several diameters on a shaft simultaneously or for wide wheel grinding applications. During the exposition, this machine will grind the main bearing diameters of the crankshaft, an operation for which this machine's predecessor, the CM-1, has been widely used.—Norton Co. Booth 651.

Circle 57 on postcard for more data

## Turret Lathes

Saddle type turret lathe includes a 24-speed headstock, 30 HP motor, an 18-inch 3-jaw scroll chuck and a turret-mounted JETracer slide tool. It will handle the first machining operation on aluminum air cylinder bodies. Chucked in the cylinder bore, the entire O.D., including the locating and mounting hubs and the small bore, will be machined in only 5.61 minutes f.t.f. The JETracer slide tool will be used to finish-trace the O.D. contour, providing a fine finish and close tolerance accuracy. — Gisholt Machine Co. Booth 1042.



Circle 58 on postcard for more data

## Jig Borer

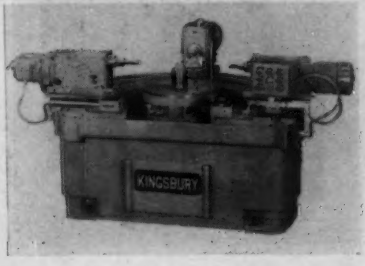
A 3-inch combination jig borer and milling machine of advanced design operates under Numeripoint tape control. Demonstration will include automatic tape and dial positioning of head and table to high accuracies featuring boring with saddle feed, and heavy milling operations in cast iron.

This new 10-hp machine with 30 inch x 48 inch table features: extra-fast positioning with repeat accuracies to ±.0001 inch, 16 inch of spindle travel at feed rates of 0.012 in. to 120 in. per minute, and automatic saddle depth positioning. An optional rotary air lift table greatly extends the productivity of the machine on many jobs. —Giddings & Lewis Machine Tool Co.—Booth 1320.

Circle 59 on postcard for more data

## Automatic Drilling

Automatic drilling and tapping machine has 20-inch index table and no center column. It is designed and built with suitable auto-



# New for Production

*More MTE Products*

matic units and special tooling to perform specified operations on one part. Machine is a fairly simple setup with three such units but no special tooling.

Left to right the three units are: a drilling unit of medium size (model 16) with 5-inch stroke; a drilling unit of large size (model 22) with 3½ inch stroke; a tapping unit of small size (model 5) with 4-inch stroke.

Each automatic unit is compact and self-contained. It can be mounted horizontally (as shown), vertically or at an angle.—Kingsbury Machine Tool Corp. Booth 731.

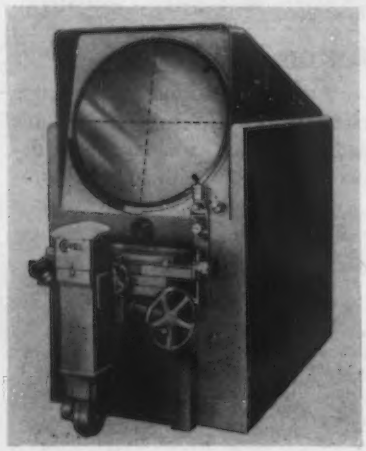
Circle 60 on postcard for more data

## Optical Comparator

Viewing screen on this optical comparator is 30 inches.

Stage uses micrometer of one inch travel for measuring both the horizontal and vertical planes with provision for measuring rods or gage blocks for the balance of the stage travel. The optical system uses relay lenses so the projection lenses are inside the cabinet.

Optics are arranged for an upright image for all magnifications.



Screen ring is graduated and has a two minute vernier.

Stage table has built-in angular adjustment 15° each way with vernier.—Covel Manufacturing Co. Booth 332.

Circle 61 on postcard for more data

## Press Brake

This 750 ton hydraulic press brake has a bending capacity of ¾ inch x 14 ft. mild steel over a 7 inch

die opening. Overall die surface is 24 ft.—The Cincinnati Shaper Co. Booth 1230.

Circle 62 on postcard for more data

## Universal Grinder

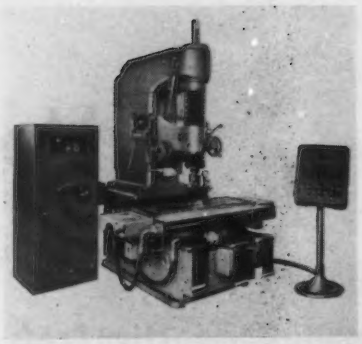
Super precision grinding of parts to 10 millionth of an inch roundness is possible on a new 10 inch Type R universal cylindrical grinder equipped with Microfeed. This machine was designed especially for precision work required in missiles, aircraft, fuel injectors, and similar close tolerance parts. Electronic gaging devices will be installed on the machine. — Landis Tool Co. Booth 823.

Circle 63 on postcard for more data

## Jig Borer

Model 65 numerically controlled jig borer features accuracy to "tenths" with high traversing speed. Table and saddle traverse simultaneously to reach each position in the shortest possible time.

Positioning accuracy is obtained from precision linear transducers. No wear can occur on these transducers since electric signals give the location of the slides without physical contact.

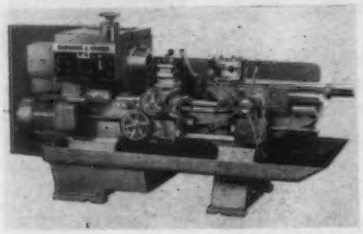


The table and saddle are driven by hydraulic cylinders operating from balanced, closed hydraulic circuits which provide automatic clamping.—W. B. Knight Machinery Co. Booth 824.

Circle 64 on postcard for more data

## Turret Lathe

Completely new No. 6 Universal ram-type turret lathe will be shown. It offers 3 inch spindle capacity for heavy duty bar work, 5 inch spin-

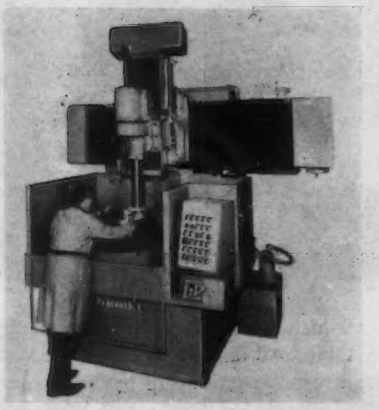


dle capacity for light duty bar work, and 21⅛ inch swing of the bed ways. Outstanding new features include automatic spindle speed changes, 50 to 1 speed range, 16 geared spindle speeds, and cross slide power rapid traverse.—Bardons & Oliver Inc. Booth 741.

Circle 65 on postcard for more data

## Precision Contouring

Contouring of nose cones and conventional grinding and turning can be accomplished on new 900 Series custom precision machines. These utilize vertical design to eliminate the deflection normally encountered when large unsupported



parts are machined in a horizontal position.

Tracer, numerical and manual control are available with extremely close tolerances.—Frauenthal Div., The Kaydon Engineering Corp. Booth 1220.

Circle 66 on postcard for more data

## Trimmer

Model 43HVX trimmer can shear mild steel stampings up to 3/16 in. thick.

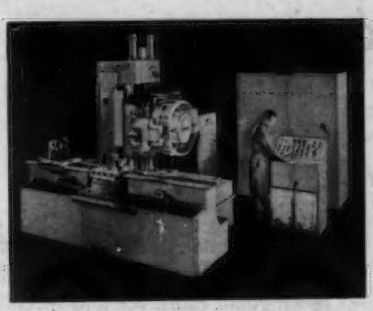
This photo shows a pneumatic holddown device on the table top,

used generally for the trimming of round stampings.—Beatty Machine and Manufacturing Co. Booth 243.

Circle 67 on postcard for more data

## Complex Machining

Self-contained "machine shop" is numerically controlled, employing a standard 1-inch wide, 8-channel punched tape. This model II "machining center" will mill, drill, bore, ream, tap, select and change its own



tools, and transfer the workpiece. All machine motions are powered by a 30 HP hydraulic unit. The three axes of motion, X-longitudinal, Y-vertical, and Z-depth, respectively, have ranges of 24 in., 20 in., and 16 in.—Kearney & Trecker. Booth 1008.

Circle 68 on postcard for more data

## Shear

Bar-billet-shear will be shearing round bars to accurate lengths. These pieces will be used in the drop forge industry. This machine will be operating at 20 strokes per minute and has a full capacity of 4 inch diameter mild steel bars.—The Hill Acme Co. Booth 1240.

Circle 69 on postcard for more data

## Milling and Profiling

Continuous path, tape controlled milling & profiling machines, are of traveling table, vertical spindle, bridge type design. This 200 series covers a broad range of sizes with multiple axis control.

Some of the outstanding features are: anti-backlash recirculating ball bearing precision screws on each axis; anti-friction unit type recirculating roller bearings on hardened and ground ways; continuously variable spindle speeds from 15 to 6000 rpm.—Ekstrom, Carlson & Co. Booth 846.

Circle 70 on postcard for more data

## Grinding Machine

Model 182 "Crushtrue" multiform grinder automatically grinds cylindrical forms and grooves on two or four parts simultaneously at

wheel speeds of 9200 s.f.p.m. and faster. It is being demonstrated publicly for the first time.

Two piston rod shafts, each approximately 3¾ in. long, will be fed into a rotating cage at the front of the machine for indexing into grind position.

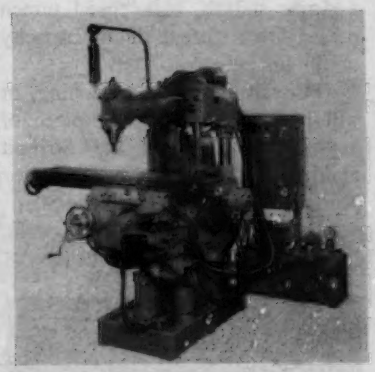
Both shafts will be ground simultaneously with one being located above the centerline of the Crushtrue dressed grinding wheels and the other below. The rotating cage indexes both parts to the unloading chute.—The Sheffield Corp. Booth 201.

Circle 71 on postcard for more data

## Automatic Scanning

Scan-O-Matic milling machine adds automatic scanning to the Greaves Model 2H heavy duty milling machine.

In the Scan - O - Matic system, tracing stylus automatically follows the contour of a master regardless



of whether it has straight walls, angles, or curves to be cut. Deflection of the stylus always remains the same, thus resulting in uniform and accurate cuts.—Greaves Machine Tool Co. Booth 1439.

Circle 72 on postcard for more data

# New for Production

*Products at the Production Engineering Show*

## Tape Controls

Transistorized Inductosyn numerical control system has punched tape input for automatic operation. It can also be operated by manual

input from rotary switch controls.

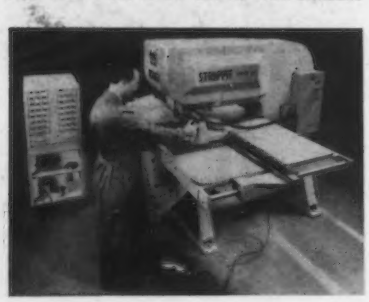
Photograph shows typical application to a jig borer. Console houses the tape and manual controls.—Farrand Controls Inc. Booth 103.

Circle 73 on postcard for more data

## Punch Press

Strippit Super 30 Fabricator is a single station, high speed punch press with a throat depth capacity of 30 in.

For straight line punching, it will handle a 30 in. workpiece of any length, utilizing the Strippit multiple-stop gauging system. For production punching with the Strippit Duplicator, its maximum work size is 30 in. x 30 in. It will handle



90° corner notching up to 5 in. x 5 in. in 16 gauge mild steel as well as rectangular, radii, vee and special edge notches—Wales Strippit Inc., Booth 340.

Circle 74 on postcard for more data

## Automatic Assembly

New concept in automatic assembly uses an improved standard assembly machine. "Pick and place" and "push and guide" actuations of integral stations result from two cams operating in a center-mounted turret.—Ferguson Machine Corp. Booths 246-248.

Circle 75 on postcard for more data

## Precision Gage

Precision bore gage and size setting fixture combination requires no gage blocks, rings or other "mas-

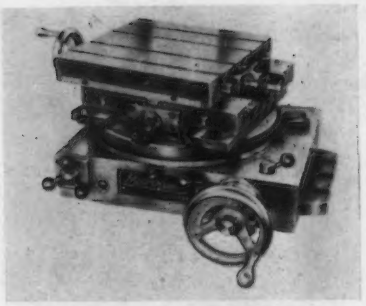
ters" to set, check or gage any hole size within its .375 in. to 2.900 in. measuring range. Settings are as simple to establish as micrometer readings. — Sunnen Service Corp. Booth 327.

Circle 76 on postcard for more data

## Cross-Slide

Cross-slide rotary table is designed to reduce set-up time. Once located and clamped on the cross-slide, it is rarely necessary to move or re-clamp the workpiece until all cuts are complete.

Slides can be adjusted to position the work for cutting any radius whose center point lies within a



9 inch square area centered on the table. All dimension points are kept in exact relationship to each other. Morrison Machinery and Engineering Corp. Booth 1543.

Circle 77 on postcard for more data

## Microscope

Toolmaker's microscope has coordinate measuring range of 2 in. x 2 in. Large diameter drums attached to the precision lead screws permit rapid reading to 0.0001 in. —The Gaertner Scientific Corp. Booth 346.

Circle 78 on postcard for more data

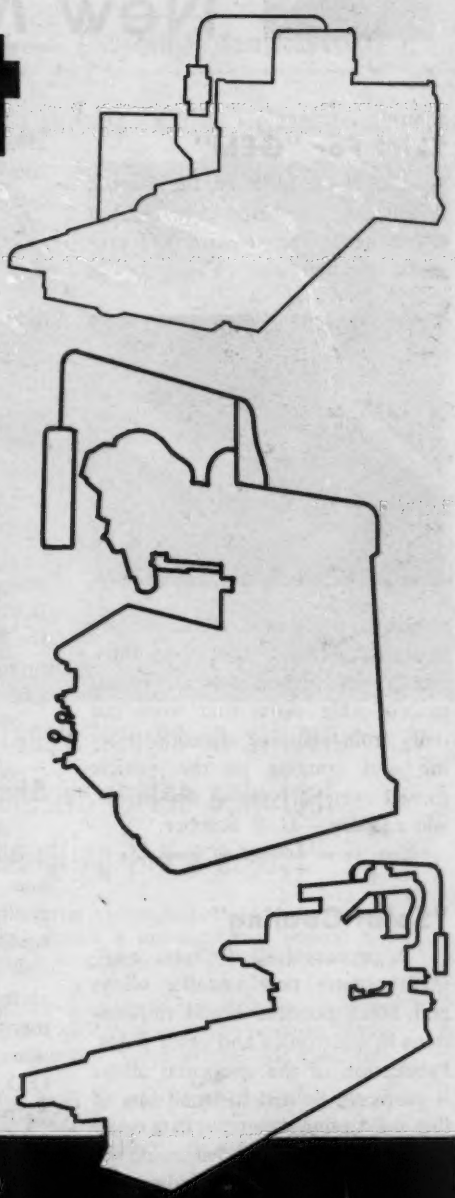
## Nondestructive Testing

Type NQ-242 testing unit is a magnetic particle unit specially tooled with loading tray, positioning fixture, bath applicator, and automatic magnetizing circuit. It is for production testing of ferrous parts up to 24 in. long. Suspended mag-

netizing heads and coil permit conveyors to be positioned either across or through the unit.—Magnaflux Corp. Booth 400.

Circle 79 on postcard for more data

# see inspect learn . . .



**all about the latest developments in automatic and conventional machines such as:**

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- Vertical Ram Type Milling Machine with tilt head and tilt table.
- 4 Axis Trace Control Profiling and Milling Machine.

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CHICAGO

# New Materials

## Skirt For "GEM"

Uscothane skirt on the Curtiss Wright Air Car helps keep cushion of air under the vehicle. The urethane product was chosen for its

abrasion resistance. Uscothane skirts have lasted more than three months of rugged testing. It replaced other skirts that wore out daily from constant abrasion, tearing and gouging as the vehicle passed over all types of conditions, wet and dry.—U. S. Rubber.

Circle 80 on postcard for more data

## "Splat Cooling"

A process (called "splat cooling") creates new metallic alloys and holds possible broad implications in electronics and other fields. Production of the abnormal alloys is currently limited to small bits of thin foil having structures that never existed before. Such foil could be utilized in fields where only small quantities of materials are required. The procedure is called "splat cooling," because it involves blasting a molten droplet of a pure metal or an alloy against the rim of a refrigerated metal wheel spinning at high speed. This cools the droplet at the rate of 2,000,000°F per second, quick-freezing the droplet as a small piece of thin foil before the atoms have time to realign themselves. A fine grain structure is created, with each individual grain too small to be seen with an optical microscope.—California Inst. Technology.

Circle 81 on postcard for more data

## Structural Ceramic

A high temperature refractory product, known as Crystolon "63," is expected to have wide application as a relatively low cost structural ceramic. It is high in physical strength and resistance to attack by heat and molten salt.

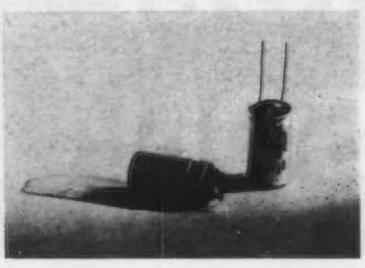
Crystolon "63" is a silicon nitride bonded refractory. It was originally developed to meet the need for better refractory linings for aluminum reduction cells. — Norton Co.

Circle 82 on postcard for more data

## Shrinking Glass

A vinyl heat-reactive tubing called Scotch Tite shrinks under heat to provide a tight covering on gently contoured shapes. It is fully transparent. Colors are also available on special order. The material shrinks under heat to its final dimensions in 4 to 8 min at 300°F. sizes range from 3/64-in. to 5 in. O.D. It is being used for covering harness cables, condensers, coils, and other items where a tight, abrasion and chemical resistant electrical insulating cover is required. —Minnesota Mining and Mfg. Co.

Circle 83 on postcard for more data



## Cobalt-Base Alloy

Improved WI-52 cobalt-base high-tungsten superalloy has better strength in the 1800°F range. It has good ductility and corrosion resistance. Improved refining techniques and precise control of the

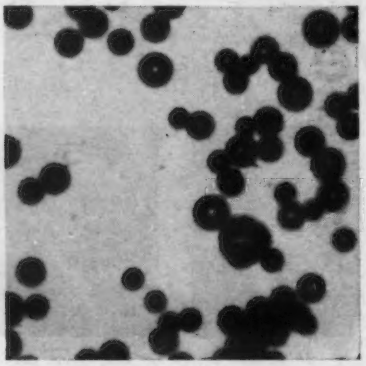
alloying elements have increased 1800°F stress rupture life by 18 per cent and rupture elongation by 160 per cent over previous alloy variations. It could serve as a turbine blade alloy. Acceptance tests at 1800°F and 15,500 psi, on 10 recent production heats, show an average stress-rupture life of 73 hr with an average stress rupture elongation in 1-in. of 17 per cent. —WaiMet Alloys Co.

Circle 84 on postcard for more data

## Uniform Powder Metal

New process produces powders of metals and metal alloys with spherical particles ranging from 20 to 150 microns. Uniformity rate is 98 per cent. Produced in a totally inert atmosphere, the tiny particles are free of such defects as voids, cavities, and inclusions. Six different powders are available in limited

quantities: copper, aluminum, nickel, 316 SS, tungsten, and nichrome. Spherical powders will



find applications in fabricating sintered bodies with controlled porosity. This suggests usage in filters, sweat cooled nozzles, porous piston rings, and the like. They may also improve rocket propellant specific impulse.—Linde Co.

Circle 85 on postcard for more data

## Germanium-Seal

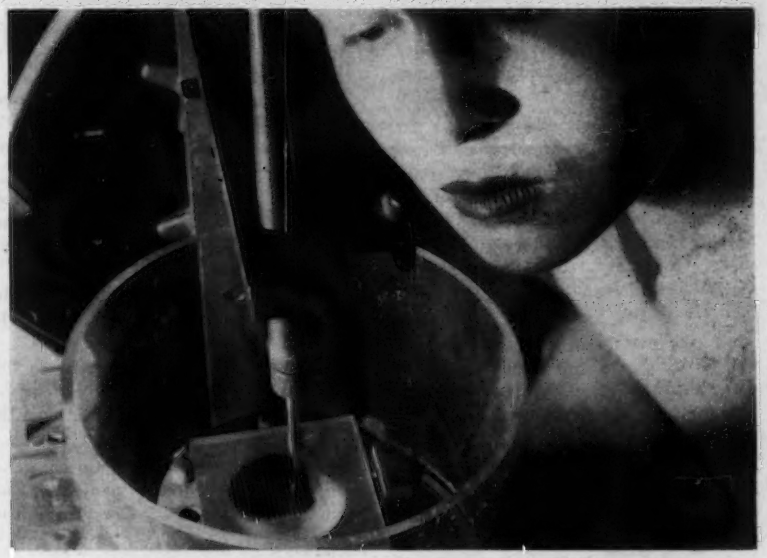
New process for sealing germanium windows to infrared detectors, makes possible the fabrication of detectors for use in longer wavelength regions. The development enables detectors to receive transmission of infrared radiation beyond 25 microns (the germanium window may be coated to peak within this range). Detectors incorporating commonly-used silicon and sapphire windows limit transmission of infrared radiation to about the nine and six micron regions, respectively.—Philco.

Circle 86 on postcard for more data

# Another "impossible" job done by the Airbrasive®...

...cutting semiconductors

abrading • cutting • deburring • stripping • drilling • cleaning • scribing



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*Send us samples of your "impossible" jobs and we will test them for you at no cost.*

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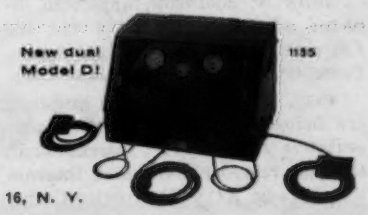



S. S. White

S. S. White Industrial Division
Dept. 18A, 10 East 40th Street, New York 16, N. Y.




Circle 29 on Inquiry Card

# Men on the Move

A. J. KULLAS, named engineering technical director for The Martin Company's rocket booster portion of the Air Force Dyna-Soar program.

EDGAR C. ANSALDI, appointed chief of the experimental test laboratories of Pratt & Whitney Aircraft division of United Aircraft Corp.

HARVEY GAYLORD, now president of the recently-formed Bell Aerospace Corp. comprised of the three former defense units of Bell Aircraft. Officers of the divisions include: WILLIAM G. GISEL, president, Bell Aerosystems Co.; EDWIN J. DUCAYET, president, Bell Helicopter Co.

A. M. (TEX) JOHNSTON, named assistant program manager for design and test on the Dyna-Soar manned space glider at Boeing Airplane Co.

MARTIN BOE, promoted to weapon system manager of the GAM-77 Hound Dog program at North American Aviation's Missile Division. ROBERT G. WILSON, named manager of the lunar soft landing study program at the division.

DR. IVAN A. GETTING, appointed president of The Aerospace Corp.

W. E. GIBERSON, appointed chief of the newly-organized Guidance and Control Div. at Cal Tech's Jet Propulsion Laboratory.

WILLIAM C. SCHUPP, CHARLES R. LAYNE and DONALD C. CHALIFOUR have joined the field engineering staff of Barnes Engineering Co.

JAMES R. KERR, named executive vice president of Avco Corp. He will head the Defense and Industrial Products Group.

JOHN W. CORCORAN, named chief scientist in the Research and Development Div. of Beckman & Whitley.

PHILIP KAHN, named president of Brilhart Plastics Corp.

DR. JAMES W. MOYER, appointed research director of the Sperry Rand Research Center to be built this year in Sudbury, Mass.

JOHN W. ROBINSON, appointed director of Public Relations for the Fairchild Aircraft and Missiles Div., Fairchild Engine and Airplane Corp.

PAUL WILSON, appointed midwestern industrial and commercial representative for "Crown" International, the tape recorder division of International Radio ADN Electronics Corp.

WOODS KING, JR., appointed assistant secretary and office counsel of The Gabriel Co.

J. R. REA, appointed manager of the Joplin, Missouri plant of the Aero Hydraulics Div., Vickers Inc.

LT. COLONEL GLENN CRANE, named project officer in charge of the Army's Nike Zeus anti-missile missile program.

DAVID E. TRUMBULL has assumed the duties of engineering manager for Western Design, Div. of U. S. Industries.

CURTIS M. LEE has joined Wyle Manufacturing Corp. as chief engineer.

HOLMES M. BROWN, selected to fill the newly created position of corporate director of communications in the Martin Co.

J. HAROLD MOORE, appointed general manager, defense projects, Defense Activities Div., Western Electric Co.

RICHARD H. HAAS, appointed manager of plastic sales for Goodyear Aircraft Corp.

FRANK P. DELUCA, JR., has been named president of Acoustica Associates and its subsidiaries. ROBERT L. ROD, founder - president, will assume the newly-created position of chairman of the board.

WILLIAM F. ROMIG has joined the staff of Cornell Aeronautical Laboratory, Inc.

KENT DOOLITTLE has been named general manager of the Western Operation of CTL Div., Studebaker-Packard Corp.

DONALD M. POWERS, named head of the newly-formed Systems Div. at Electro-Mechanical Research Inc.

JAMES H. MC GARRY, appointed director of manufacturing for the Mechanical Div. of General Mills.

DR. S. J. GERATHEWOHN, appointed head of operational development in NASA's Office of Life Science Programs. DR. RICHARD S. YOUNG, named chief of flight biology.

KARL T. WILDER has joined the Information Technology Div. of Lockheed Electronics Co. as senior scientist in the Computer Systems group.

DAVID F. SHAW, named general manager of General Electric's Aircraft Nuclear Propulsion Department.

J. R. Rea
Vickers

Lt. Col. Glenn Crane
AOMC

David E. Trumbull
Western Design

Curtis M. Lee
Wyle Manufacturing Corp.

Holmes M. Brown
The Martin Co.

J. Harold Moore
Western Electric

Richard H. Haas
Goodyear Aircraft

Frank P. DeLuca Jr.
Acoustica Associates

William F. Romig
Cornell Aeronautical Laboratory

Kent Doolittle
CTL

# New Books

AEROSPACE MARKETING HANDBOOK. Edited by William E. Larned, Jr. Defense Marketing Services, 1960. Subscription rate: $175, including eleven monthly supplements. This is a comprehensive reference, bound in loose-leaf form. It covers the missile, rocket, and space programs of the United States Government, and is intended as a sales aid for management and marketing men in the aerospace industries. Contents include: an alphabetical index to programs; an alphabetical section with tabs, on each program; location of government agencies; and separate indexes on categories, designations, cognizant agencies and the status of current programs.

RANDOM VIBRATION. Edited by Stephen H. Crandall. Technology Press & Wiley, 1959. 423 pp., $8.50. The material presented in this book is intended for engineers already versed in fundamental problems of mechanical vibration. The author has endeavored to provide additional and newer tools for extending ordinary vibration theory into the field of random vibration theory. The subject matter is of vital interest especially for the engineer who is confronted with the severe vibration environment produced by modern rocket and jet engines. First six chapters treat basic concepts and background material; last six chapters deal with the problems of design and testing.

KINETICS OF HIGH-TEMPERATURE PROCESSES. Edited by W. D. Kingery. Technology Press & Wiley, 1959, 326 pp., $13.50. Treating of kinetics of condensed-phase processes at elevated temperatures, the context of this book is drawn from an international Conference on the Kinetics of High-Temperature Processes held at M.I.T. on June 23-27, 1958. Subject matter is approached from the disciplines of chemistry, ceramics, metallurgy, and physics. The studies are grouped under seven headings as follows: Imperfections and diffusion in nonmetals; diffusion in liquids and liquid-solid reactions; nucleation and grain growth; sintering and vitrification phase transformations; solid-solid reactions; and solid-gas reactions.


FPD PROFESSIONAL EMPLOYMENT NEWS

PUBLISHED BY THE FLIGHT PROPULSION DIVISION OF GENERAL ELECTRIC IN CINCINNATI, OHIO / SEPTEMBER, 1960

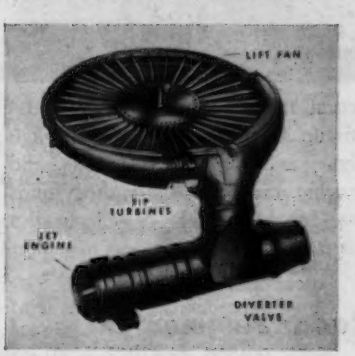
FPD NEWS offers latest information on openings throughout the Division to interested engineers and scientists. Technical information and news relating to current projects will also appear from time to time in this column.

## New Lift Fan to Boost Performance and Efficiency of VTOL Aircraft

Creating propulsion systems for advanced VTOL aircraft capable of high subsonic or supersonic speed presents engineering problems that challenge the ingenuity of both the theoretician and design engineer.

With a VTOL machine, take-off thrust must exceed the vehicle gross weight with some margin, whereas only a small fraction of this power will be required for cruise. Optimizing the engine size for *both* flight regimes becomes a formidable task.

One of the concepts recently advanced by Flight Propulsion Division engineers is the lift fan illustrated in the drawing at right. Now, selection of the gas generator can be based on optimum jet-powered cruise performance.



For a given engine, fan lift is a function of fan pressure ratio and diameter. The fan provides greatly augmented thrust for the take-off mode, as verified in a recent test of a prototype configuration utilizing a G.E. J85 turbojet; the "straight-through" 2500 pounds of thrust produced by this engine was boosted to 7500 pounds for vertical flight by its lift fan.

But this is just the beginning. Developments to come will include lighter and larger fans, integrated with more powerful gas generators. We anticipate that vertical thrust/weight ratios, now about 9:1, will be elevated to 15:1 by 1965. Such propulsion systems will permit the evolvement of a new class of air vehicles for the military and, ultimately, for commercial applications.

▸ ***Immediate Opportunities on VTOL Programs, and in Other Expanding FPD Components:***

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**Rocket Engine Development**
**Nozzle Development & Design**
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**Mechanical Design Engineering**
**Manufacturing Engineering**
**Reliability & Quality Control**
**Applications Engineering**
**Electrical Space Power and Propulsion Systems Development**
**High Temperature Metallurgy**

Write informally, or forward your resume in confidence to Mr. Mark Peters, Dept. 125-MI, Bldg. 100.

**FLIGHT PROPULSION DIVISION**

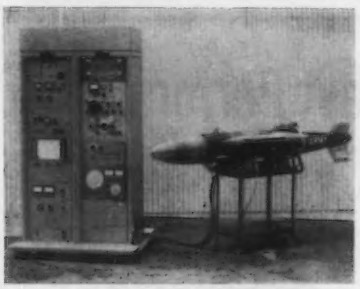
**GENERAL ELECTRIC**

**CINCINNATI 15, OHIO**

# New Electronic Products

## Checkout Equipment

System tests the performance of RP-76 rocket-powered target missile's tracking, guidance, radio and safety equipment. It simulates an

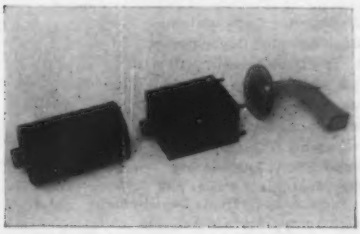


actual flight sequence from initial missile launch at altitude through flight and recovery. Visual and graphic records on all subsystems are provided. — R S Electronics Corp.

Circle 87 on postcard for more data

## Radar Augmenter

System is for increasing radar detection range and probability of detection of objects with small radar cross-sectional areas. It simulates a 30 sq meter target at X-band with 45 deg x 20 deg coverage in pulse operation and 100 sq meters



with OMNI coverage for CW operation. Augmenter displays similar performance at other bands; it functions as a phase coherent repeater and/or precise frequency translator with 35 db gain for 1 micro-second pulses and over 60 db gain for CW signals. Simulated doppler output (from 10 cps to over 1 MC) exceeding milliwatt with —50 dbm input signals can make stationary or slow moving targets assume ICBM characteristics. Suitable for installation in missiles, drones, targets, rockets or test laboratory environments.—Emerson Electric Mfg. Co.

Circle 88 on postcard for more data

## Ultrasonic Tester

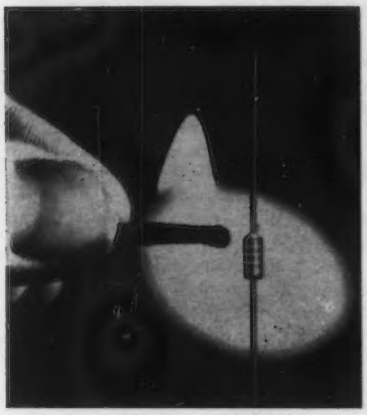
Fully transistorized battery-operated ultrasonic tester measures wall thickness between 0.025 and 2.50 in. The portable unit, designated Sonizon SO-300, gives instant reading by simply placing a transducer on surface to be measured

and turning a dial. It is housed in a high impact-proof plastic case measuring 8½ x 9½ x 11¼ in. A separate carrying case for batteries is equipped with shoulder straps for use outdoors.—Magnaflux Corp.

Circle 89 on postcard for more data

## Silicon Zener Diodes

Tri-Sealed diodes for voltage regulation circuits measure 0.300 x 0.125 diam (not counting leads) and are rated at 200 milliwatts power dissipation. A complete series of 17 types cover the 5.6 to 27 volt range, and are designated Types XSZ 5.6 through XSZ 27. Units demonstrate low zener impedance values and sharp zener "knees" for optimum voltage regulation. All types feature a 3-barrier sealing process giving high resistance to



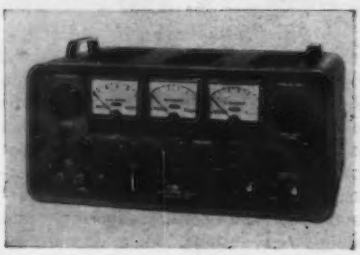
humidity, shock and vibration over a temperature range from —20° to 130°C.—International Rectifier Corp.

Circle 90 on postcard for more data

## Microwave Modulator

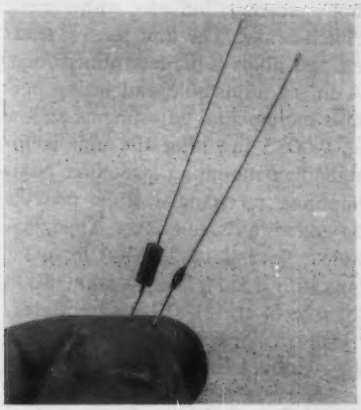
Model 10003 modulator, is for operation with beacon type magnetrons such as are used in navigational radar, and available for other applications with similar requirements. It measures 8½ x 18 x 12 in., and contains an internal generator providing a pulse width 200 to 4,000 pps; pulse voltage from 0 to 5 KV; and pulse current of 2 amps max. Pulse repetition rate is continuously variable from 0.4 to 2.2 microseconds. Silicon rectifiers conserve space and provide freedom from excessive heat. Safety features include automatic sequencing, overload sensing and discharge circuits. Weighs 45 lb.—Narda Microwave Corp.

Circle 91 on postcard for more data



## Capacitors

Ceramic capacitors named Ceramin, measure (less leads) 0.250-in. long. They come in 0.098-in. diam for capacitances from 47 to 560 mmf, and 0.125-in. diam from 680 to 1200 mmf when fully encapsulated in glass. They are also available temporarily-cased in flexible epoxy for use in unitized, customer-potted assemblies. These barium - titanate capacitors are precision-tuned to

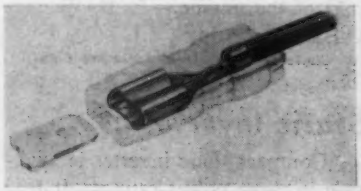


±5 per cent tolerance to 125°C or ±10 per cent to 150°C and meet the applicable requirements of MIL-C-11015A and EIA-SMC-1 specifications.—Electramics Corp.

Circle 92 on postcard for more data

## Terminals In Chain

Tabon terminals for quick connect/disconnect applications are available in chain form for rapid machine crimping. They eliminate



hand labor and assure uniform quality. Made with large radii for quick, easy insertion; they are vibration proof and assure constant uniform electrical contact over the full length of mating areas. Made in a wide range of wire and insulation sizes, they are of self-wiping and self-cleaning design. Crimp machine is also available for high production.—Malco Manufacturing Co.

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CONTROLLED TEMPERATURE SOLDERING IRONS

. . . with advanced features for greater efficiency, longer life.

- **VARIOUS TIP TYPES AVAILABLE.** Made of copper for fast heat transfer and premium iron plating for long life—with built-in Magnastat sensing device.
- **NEW TIP RETAINING NUT MINIMIZES FREEZING.** Seals tip receptacle from flux fumes.
- **NEW RUBBER SHOCK ABSORBER.** Also prevents iron from sliding off bench.
- **NEW, RUGGED, NON-ARCING SNAP SWITCH.** Guarantees continuous, reliable service.
- **PLASTIC HANDLE.** Extra strong—cooler handling.
- **ADVANCED CORD CONNECTION.** Locks cord securely in place, yet permits easy replacement.
- **2 or 3-WIRE CORDS NOW AVAILABLE** for all models. Cords are flexible and light in weight.

Remember, too, Weller Magnastat Soldering Irons automatically maintain the correct soldering temperature—never overheat. They weigh only half as much as uncontrolled irons and give greater heat efficiency with lower wattage. This means more reliable soldering, less down time.

Model TC-552 provides

**2 SOLDERING TEMPERATURES**

. . . low heat for heat-sensitive soldering . . . higher heat for regular work. Accomplished by interchanging high and low heat tips. 55 watts.

$9.00 list

**2 other Magnastat Soldering Irons are available**

**MODEL TC-602.** 60 watts, for light to medium electrical soldering. $10.00 list

**MODEL TC-1202.** 120 watts, for medium to heavy electrical soldering. $11.50 list

*Prices shown are for Magnastat Iron including tip and two wire cord.*

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**features "building block" components arranged for completely automatic finishing cycles**

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Power, Paint and Maintenance Brushes • Foundry Production Machinery

# New Electronic Products

## Linear Actuator

Model 3080, 400-cycle linear actuator, qualifies to MIL specifications, features an electro-magnetic clutch-brake. The unit senses, shuts off and holds a predetermined load. A micro adjustable end fitting permits incremental adjustments as low as 0.0035 in., after the unit is installed in mounting structure. Nonjamming mechanical stops provide an added fail safe feature. Specifications: Normal load, 2200 lb; max. operating load prior to stall, 8000 lb; rate of travel, 0.12in./sec; electrical stroke, 3.125 in; weight, 8.1 lb.—Hoover Electric Co.

**Circle 94 on postcard for more data**

## Umbilical Connector

Electrical umbilical connector disconnects by shearing action. It is being used to activate Polaris missile into controlled power flight from underwater. 126 pins (4 through 20 contact size) with spring leaf contacts and two ½ in. water methanol electronic cooling lines are integrated into one compact connector plug. This mates with an airborne receptacle that is an integral part of the missile.—E. B. Wiggins Oil Tool Co., Inc.

**Circle 95 on postcard for more data**

## Static Inverter

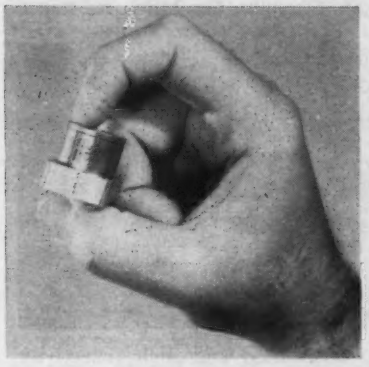
Compact static inverter is available in three power ratings. It features fast response, low distortion, and lightweight design. These single phase inverters provide reliable 400 cps power source for airborne, missile or other applications. Transistor circuitry makes possible small sizes, ranging from 4 x 7 x 4 in., six lb, to 7 x 10 x 6 in., 20 lb. Aluminum base is utilized to conduct heat away from components. —Curtis Winters Co., Inc.

**Circle 96 on postcard for more data**

# New Parts and Components

## Accelerometer

Temperature-compensated Type 4-202 strain-gage accelerometer is a linear unbonded, bi-directional instrument, for measuring accelerations perpendicular to its mounting surface. Weighs less than 3 oz; measures 1 in.$^3$ Has linearity and hysteresis rated at less than ±0.75 per cent of full range output. Temperature compensation allows static accuracy from −65° to +250°F.



Standard ranges are from ±5 to ±500g. Input voltage is five volts with a full range output of 40 mv (±20 mv). — Consolidated Electrodynamics Corp.

Circle 97 on postcard for more data

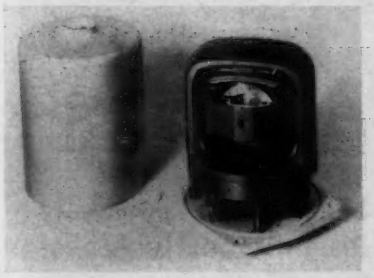
## High-Tensile Wire

With a tensile strength of 575,000 psi (about twice the strength of the strongest ordinary carbon steel wire) the new wire is combined with plastics to form cases to contain solid fuels for rockets and for high pressure containers. — National-Standard Co.

Circle 98 on postcard for more data

## Gas-Driven Gyro

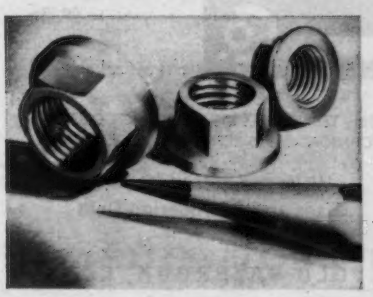
The "Genie" is intended as a reference instrument for short-range missiles, drones and target vehicles. Features claimed include: design simplicity, a low drift rate, instantaneous start time and long storage life. Gyro is designed for a drift rate of 2 to 4 deg per min under extreme missile environments; only electrical elements are pick-offs, and a firing squib. Initial version, using commutator switch pick-offs, can readily be adapted to either potentiometer or magnetic pick-offs.— Lear, Inc.



Circle 99 on postcard for more data

## High-Temp Nut

FN 1014 featherweight locknut for 1000°F applications is rated at 145,000 psi. It exceeds tensile strength, maximum usage temperature, magnetic permeability and locking torque requirements of NAS 1291C. FN 1014 nuts are forged from A-286, heat and corrosion resistent alloy, and are silver plated to AMS 2410 standards. Integral self-locking feature provides a 3-point positive lock. An alternate series, designated FN 1014M, finished with a molybdenum disulfide dry film lubricant is also being made available for moderate temperature usage. It is for electrical applications where low magnetic permeability is required. Both types are made in standard Class 3B sizes from #4-40 through ⅜-24. — Standard Pressed Steel Co.



Circle 100 on postcard for more data

## Electronics Cabinets

Prem-O-Rak sloped-front console, consists of a frame and end panels. Designed for custom packaging both singly and for multiple installations. Front and rear panel mounting angles are adjustable to any desired position. A cutout is provided in the bottom for leads, etc. Holes are punched to accommodate casters. Frames are finished in gray Hammertone; end panels in brown Hammertone. — Premier Metal Products Co.

Circle 101 on postcard for more data

## Traveling-Wave Tubes

Type TW-4002F and TW-956H are temperature compensated, magnetically shielded, traveling wave tubes, for "close quarters" in airborne and missile applications. Designed for pulse and CW operation, both use periodic permanent focusing; both operate without heater blankets from −65° to 72°C with minimum performance degradation. They have a relatively flat frequency response over an octave,

*continued on following page*

# Proved! New, Better Way to Seal Drilled Holes with . . .

***Less weight!***

***Less cost!***

***NEW PIN-PLUGS°***

## Seal simply, positively Prevent costly leaks!

Now — forget conventional, costly methods of sealing holes that serve as flow or pressure passages. The Lee "Pin Plug" is a cylindrical plug with a tapered reamed hole partway through its center and numerous small grooves on its outside surface. Simply place it into reamed hole and drive in the tapered pin until ends are flush. Controlled expansion causes grooves in plug to "bite" into casting and form independent seals and retaining rings. Extensive laboratory tests report no leaks under normal pressures, often show bone dry seals up to pressures of 40,000 psi.

Now successfully and widely used on aircraft and missiles — for pumps, servo valves, regulators, etc. Available steel and aluminum and in both long and short series.

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# New Parts and Components

from 2.0 to 4.0 KMC. Each unit weighs approximately three pounds, is about 15 in. long, and has a 1.4-in. capsule diam.—Sylvania Electric Products.

Circle 102 on postcard for more data

## Radiometer Reflector

Made of cobalt-base alloy No. 25, the reflector is for airborne radiometers used by Naval Research Lab. Strength, durability, resistance

to tarnishing, and high reflectivity in the infra-red range were reasons this alloy was chosen. — Haynes Stellite Co.

Circle 103 on postcard for more data

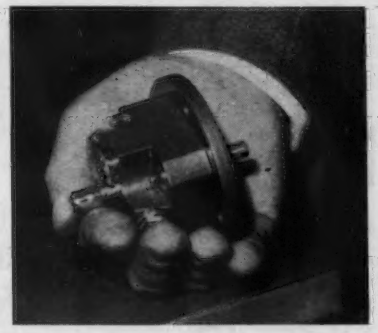
## Ball Valve

"Free-Turn" ball valve is designed for service with both non-corrosive and corrosive liquids and gases under extreme pressure and temperature conditions, especially in cryogenics and in atomic-reactor installations. It can be adapted for remote control. Special Geneva seal lifting mechanism offers increased mechanical advantage at the nearly closed position where hydrodynamic forces are greatest, and provides a positive lock at both open and closed positions.—Dyna-Matics Corp.

Circle 104 on postcard for more data

## Dual-Purpose Pump

A hydraulic unit, works either as a pump or motor; has missile applications. As a motor it is capable

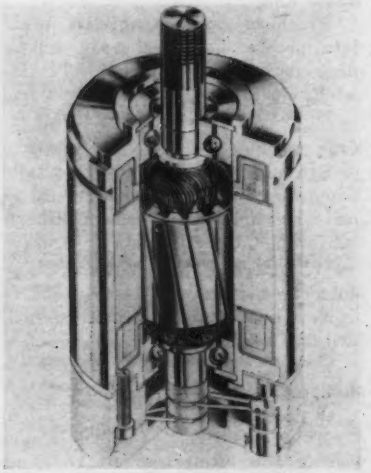


of exceeding 40,000 rpm. As a pump it can produce line pressures of up to 2000 psi. It consists of a bronze cylinder block which houses seven radially-disposed pistons. Cylinder rotates around a hardened steel distributor shaft and the pistons bear against a circular track which is placed eccentrically to the central shaft. Mounting arrangements and connecting methods are available to suit individual requirements.—Boulton Paul Aircraft.

Circle 105 on postcard for more data

## Synchros

A new line of Size 11 synchros meet or surpass MIL-S-20708 specifications. Special potting compound makes possible operating stability throughout temperature range of 55° to 85°C. Higher temperature



range units with these same characteristics (−55° to 200°C) are available on special request. Units are available in accuracy of 3 min of arc.—Norden.

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Washington Steel Corporation is the exclusive supplier of stainless skin for the ATLAS program for a very good reason: it has been able to meet the exacting specifications laid down for this specific undertaking.

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*ATLAS—The Story of a Missile
*by John L. Chapman,* ©1960

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Into orbit goes a product of years of exhaustive research.
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For years Wall Tube's depth of experience has met the demands of even the most exacting tests. Seamless and welded stainless steel tubing of the highest quality is the Wall Tube standard.
Our representatives are anxious to demonstrate the reliable Wall tubing line. Investigate this vital new source today!
RANGE OF MANUFACTURE
Stainless Steel — Welded and Cold Drawn — 1/8" OD to 3 32" OD, .083 to .088 walls. Seamless—5/8" OD to 3 32" OD, 049" to 008" walls. Nickel and nickel alloy — seamless, 5/8" OD to 3 32" OD, .049" to .008" walls.
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NEWPORT, TENNESSEE
Circle 34 on Inquiry Card


# Worth Asking For

**Corporate Brochure**
Brochure illustrates, describes scope of firm's activities.—*The Martin Co.*
**Circle 107 on postcard for more data**

**AFMTC**
Brochure illustrates activities at ARDC's Missile Test Center, Patrick Air Force Base.—*Air Force Missile Test Center.*
**Circle 108 on postcard for more data**

**Numerical Control**
Circular on numerically-controlled equipment.—*Pratt & Whitney Co.*
**Circle 109 on postcard for more data**

**3 M Products**
Booklet describes firm's products for the aerospace age.—*Minnesota Mining and Manufacturing Co.*
**Circle 110 on postcard for more data**

**Servomanometers**
Bulletin 500 on servomanometer line.—*Exactel Instrument.*
**Circle 111 on postcard for more data**

**Hydrogen Embrittlement**
Special report makes recommendations for eliminating hydrogen embrittlement in threaded fasteners.—*Standard Pressed Steel Co.*
**Circle 112 on postcard for more data**

**Goodrich Resources**
Folder shows firm's products, materials for missiles.—*B. F. Goodrich.*
**Circle 113 on postcard for more data**

**NERV**
Four-page brochure, describes the Nuclear Emulsion Recovery Vehicle that will be used to obtain a profile picture of the Van Allen Radiation Belt.—*Missile and Space Vehicle Department, General Electric Co.*
**Circle 114 on postcard for more data**

**Amcel**
Twenty-page two-color brochure introduces firm's purpose, personnel and plant.—*Amcel Propulsion Inc.*
**Circle 115 on postcard for more data**

**CECO**
Booklet describes products, facilities and capabilities.—*Chandler Evans Corporation.*
**Circle 116 on postcard for more data**

**Shaw Process**
New 56-page brochure describes the Shaw Process precision casting technique.—*Shaw Process Development Corp.*
**Circle 117 on postcard for more data**

**Superfinishers**
Catalog explains Superfinish process; shows various machines, floor plans.—Gisholt Machine Co.
**Circle 118 on postcard for more data**

**RF Connectors**
Wide range of TNC types described.—General RF Fittings Inc.
**Circle 119 on postcard for more data**

**Portable Air Tools**
Tool selection manual concentrates on Torque ranges from 2 in. lb. to 160 in. lb.—Master Power Corp.
**Circle 120 on postcard for more data**

**Numerical Control**
Booklet on numerically-controlled machine tools.—Ex-Cell-O Corp.
**Circle 121 on postcard for more data**

**Plastic Guide**
Pocket guide to drill sizes and material thickness for use with Cherry Rivets.—Cherry Rivet Div., Townsend Co.
**Circle 122 on postcard for more data**

**Graphite Cloth**
Detailed property data on graphite woven fabrics and their relation to industrial applications. — National Carbon Co., Div. of Union Carbide Corp.
**Circle 123 on postcard for more data**

**Waste King**
Brochure shows capabilities in air data probes, hose reel gear drives, other aerospace equipment.—Technical Products Div., Waste King Corp.
**Circle 124 on postcard for more data**

**X-ray Machine**
Brochure explains how hospital's Van de Graaff accelerator is turned to part-time industrial use. — Southern California Cancer Center.
**Circle 125 on postcard for more data**

**Motor Generators**
New line of motor generators described.—Leach Corp.
**Circle 126 on postcard for more data**

**Multipress**
Complete description of operation of Multipress line. — Denison Engineering Div., American Brake Shoe Co.
**Circle 127 on postcard for more data**

**Centerless Grinder**
Catalog 1328 on new straddle-bearing centerless grinder. — Norton Co.
**Circle 128 on postcard for more data**

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- Economic Survey of Metropolitan Miami
- Metropolitan Miami Manufacturers' Directory

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**Shielded Enclosures**

Design features, general description of mobile shielded enclosures.—*Ace Engineering & Machine Co.*

Circle 129 on postcard for more data

**Crystal Oven**

Bulletin RF-594 includes design of stabilized-temperature change-of state crystal oven.—*Robertshaw-Fulton Controls Co.*

Circle 130 on postcard for more data

**Test Accessories**

Catalog 5-60, electronic test accessories.—*Pomona Electronics Co.*

Circle 131 on postcard for more data

**Noise Measurement**

Bulletin on Model 315 resistor-noise test set.—*Quan-Tech Laboratories.*

Circle 132 on postcard for more data

**Components**

Catalog on thermistors, varistors. Form V 383 on "Chopperette" switching device. — *Victory Engineering Corp.*

Circle 133 on postcard for more data

**Martin-Denver**

Brochure is an illustrated reprint of reporter's articles about his tour of missile plant.—*The Martin Co.*

Circle 134 on postcard for more data

**Tachometry Applications**

Bulletin on ways of monitoring or controlling rotating units. — *Waugh Engineering Co.*

Circle 135 on postcard for more data

**J85**

Bulletin GED-4095 is new illustrated description of turbojet, including STOL and VTOL uses.—*General Electric Co.*

Circle 136 on postcard for more data

**De-Icers**

Bulletin on firm's pneumatic de-Icers. — *B. F. Goodrich Aviation Products.*

Circle 137 on postcard for more data

**Cleveland Automatic**

New bulletin on 3 inch Model "AB" Cleveland Dialmatic with 112 spindle speeds.—*The Cleveland Automatic Machine Co.*

Circle 138 on postcard for more data

**Milwaukee-Matic**

Manual WS-59 aims at giving management complete picture of Milwaukee-Matic system and how machines operate.—*Kearney & Trecker.*

Circle 139 on postcard for more data

**Adel Activities**

Bulletin on products, facilities.—*Adel Precision Products.*

Circle 140 on postcard for more data

**New Refractory**

Data on CRYSTOLON 63 silicon carbide.—Norton Co.

Circle 141 on postcard for more data

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Amazing brazing? It is to some.

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# Industry Notes

## NASA Briefs Industry

The National Aeronautics and Space Administration has given industry new facts about coming experiments. NASA told 1300 government, industry and university officials at a Washington briefing:

- Procurement action is underway in the Orbiting Astronomical Observatory program. Procurement action on the Orbiting Geophysical Observatory (geodetic satellite) program begins in four to six months. These will embody the concept of standardized satellite units (similar basic structures used for a number of flights).

- Astronomical observatories, weighing an estimated 3500 lb., will be part of NASA's large satellite program calling for at least four 500-3500 lb. satellites each year by 1964. The "OAO" satellites will be procured through NASA's Goddard Space Flight Center.

- Specific items to be procured for NASA satellite systems will include ion mass spectrometers, vacuum gages, radiation detectors and analyzers, ultraviolet and X-ray detectors and analyzers, directional magnetometers, plasma probes, telescope pointer controls. In NASA planning, about 100 sounding rockets will be launched a year by 1962; six "small" (under 500 lb) satellites will be launched yearly by '63.

- Development team for Surveyor, a vehicle for soft landing a 100 to 300-lb payload on the Moon, will be selected by early 1961. Project, using Centaur, is slated for 1963-64 launch; later versions may use Saturn. Another lunar soft-landing spacecraft will be dubbed Prospector.

- Later phases of Project Ranger, which calls for lunar impact in 1962, will have survivable capsule and seismometer. Capsule is being developed by Aeronutronics.

- Version of lunar spacecraft, differing primarily in instrumentation, will be used on early planetary missions to Mars and Venus. (Project Mariner).

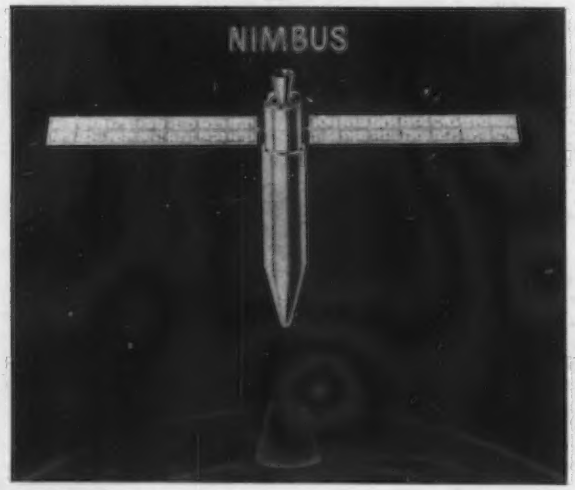
- Future procurement for lunar and planetary missions will include following types of environmental instruments: micrometeoroid detectors, pressure temperature and ionization gages, sound detectors and analyzers, mass spectrometers.

- Following observational instruments are also needed for these missions: television equipment, radar (to be utilized on lunar surface and in orbit), spectrometers, seismometers, magnetometers, penetrometers, chemical analyzers, microbiological equipment, gravimeters.

- NASA's Langley Research Center is evaluating bids for studies of rigidizing reflective structures which will be considerably larger than Project Echo 100-ft diam satellite. One of these large reflectors is slated for launch in 1962. NASA referred to entire program of passive communications satellites as Project Rebound.

- Development of Aeros stationary meteorological satellite may begin in 1962, with possible launching in 1964.

*continued on next page*




**NIMBUS I** advanced meterorological satellite is to be launched into polar orbit. TV and infrared subsystems are pointed at Earth in lower portion of satellite.

**SURVEYOR** is project for soft-landing a 100-300 lb. payload on lunar surface. Four studies are underway and development team may be selected early in 1961.

• Contract for design, engineering and fabrication of the Apollo advanced spaceship will probably be awarded in Fiscal 1962. Apollo is to be able to carry three men around the Earth or Moon. Project will be directed by the Space Task Group which is now managing Mercury. First Earth-orbit may come in 1966.

• Nimbus, advanced meteorological satellite, is slated for the latter part of 1961. This will be a 600-700-lb follow-on to Tiros. Prime contractor may be picked this Fall.

(The Astronomical Observatory satellites will carry telescopes for precise studies of sun and stars. Data is expected to increase knowledge of both the Earth's environment and the space environment.

NASA indicates that the OAO project may eventually include 24-hour synchronous satellites. The telescopes are expected to be about 36 or 40 inches in diam. They are to be pointed at a star within one second of arc for about 40 seconds.)

The 650 lb Nimbus payload will be boosted by Thor-Agena B to an altitude of about 600 miles. Orbit will be circular and inclined about 80°, slightly retrograde, so that the plane of the orbit always includes the Earth-Sun line. Satellite will always pass over local areas at local noon.

The three subsystems of Nimbus will be: power subsystem using two paddle structures covered with solar cells; stabilization subsystem using pneumatic jets and inertia wheels to keep satellite pointed directly at Earth with accuracy of 1° in all three axes; sensory subsystem including improved TV vidicon providing almost complete coverage of the globe.

Jet Propulsion Laboratory will execute the lunar, planetary and interplanetary programs under NASA direction.

NASA expects to spend $15-billion in the next 10 years on space exploration. The briefing was regarded as a move to invite further industry participation. An estimated 75 per cent of the money is to go to industry and institutions.

**NASA's Major Target Dates**

**1960**—Fire astronaut in nose cone of rocket.

**1961**—Launch astronaut into orbit, hit moon with instrumented package, launch first powerful Centaur upper-stage booster rocket.

**1962**—Launch first instrumented probe to vicinity of Venus or Mars or both; launch first 1,500,000-lb-thrust Saturn booster.

**1963**—Send unmanned spacecraft to controlled landing on moon.

**1964**—Launch an orbiting astronomical observatory.

**1964**—Send first unmanned spaceship around moon and back; attempt first reconnaissance of Mars or Venus with an unmanned vehicle.

**1965**—Make first test flight of nuclear second-stage rocket.

**1965-1967**—Fire first rockets in program leading to manned flight around the moon and to a near-Earth space station.

**After 1970**—Manned flight to Moon and back.

**OAO PROJECT** will orbit telescopes to study stars. Telescope platform at Ames Research Center is supported on air bearing in stabilization studies.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In aircraft and missile development, where success hinges on extreme accuracy, Airetool grinders meet and exceed most requirements for precision grinding and fine finishing of dies and metals. Rugged, air-driven motors supply power to spare; strong, lightweight construction stands up under constant use; perfect balance makes handling easy.

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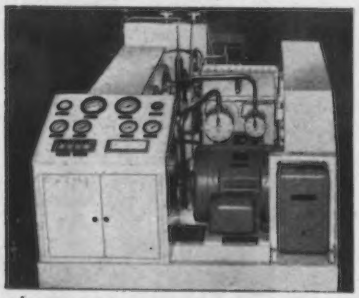
Systems can be provided from stock with *guaranteed* purification of delivered gas to —100°F. dew point and less than 4 ppm oil content. Specially engineered systems to meet your particular requirements can be supplied from standard components.

This performance is *demonstrated* by exacting rocket and missile service and continuously growing use by prime contractors, suppliers of missile components and controls, and testing laboratories. It is *backed* by over 20 years of compressor design and application experience.



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# Industry Notes

## Project LAMP

Lunar Analysis and Mapping Program (LAMP), in progress under direction of the Army Corps of Engineers, includes three distinct projects:

- The production of a 1:5,000,000 scale lunar topographic map based upon presently available lunar photography. This map, currently being compiled by photogrammetric procedures at the Army Map Service, will be controlled by selenodetic data being derived from the measurement of 56 carefully selected lunar photographs. The measured X, Y, and Z coordinates on these photographs will be tied to the datum established by Watts of the U. S. Naval Observatory for the lunar limb.
- Detailed studies related to means of acquiring lunar photography from near-earth based platforms such as balloons sent aloft to an altitude of approximately 100,000 feet. Image resolution in photography taken from such an aerial platform should enable more accurate mapping to be accomplished and more detailed petrological studies of the moon to be prepared.
- Detailed systems studies incorporating radar interrogation techniques and photographic sensing from moon-orbiting vehicles as a means of gaining information in support of hard and soft landings on the moon.

## Handbook in Demand

The Second Annual Missile Handbook can still be obtained from The Association of Missile & Rocket Industries (AMRI), 1226 National Press Building, Washington 4, D. C. Price is $4, including updatings through July.

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Rubber ducts must not crack even though frozen hard and brittle by liquid nitrogen. Access door seals must remain a rubbery seal despite high skin temperatures. Rubber parts must be "ready-to-go" even after long storage without signs of aging cracks. Chrysler Missile Division engineers specified Silastic to help keep the Jupiter ready . . . Silastic, flexible from —130 to 500 F and ageless in storage.

Photo courtesy Chrysler Missiles Division

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## Packaging an Echo

Project Echo's .0005-inch-thick mylar satellite was 157 feet long when laid out on a work table at the Langley Research Center. In packing the plastic for its space mission, residual air was forced out through 242 pin holes. Fabric was then folded into 26½-inch magnesium container. This payload was placed in a pressure chamber for final evacuation of air.

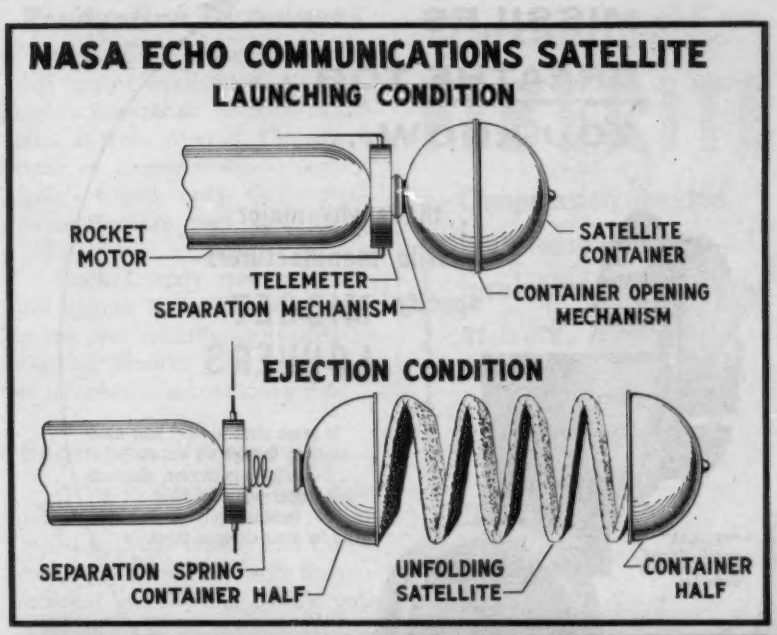
Packaging took place in a special plastic facility at Langley. It was only one step in a processing procedure which took about one month.

Container was built by Kaiser Fleetwings Inc. to Langley drawings. On arrival at Langley it went through intensive vibration and pressure tests. O ring seals were used for vacuum sealing.

Satellite, manufactured by the G. T. Schjeldahl Co., included about five miles of seams. It was inspected on special folding table on arrival. It was then inflated to its full 100-ft.-diam.; solar-powered beacons were installed; satellite was deflated, and folded into its canister. Dynamic balancing and pressure tests followed.

Vapor depositer for inflating Echo was made by National Metallizing Co., Div. of Standard Packaging. Radio Corp. of America made the beacons.

Langley is now evaluating bids for studies of rigidizing larger reflective structures. First of these large passive communications satellites may be launched in 1962.



**HEMISPHERICAL SECTIONS** fit together. They are split apart during orbit by an explosive charge. Satellite then inflates automatically. Cotton strings inside section (foreground) allow air trapped in folded satellite to follow their course and escape.

**PRESSURE CHAMBER** is used for final evacuation of air trapped inside satellite and container.

**VIBRATION TESTING** is one part of rigorous checkout procedures at Langley Research Center.

**ECHO PAYLOAD** comprises 31,416 sq. ft. of aluminized mylar folded inside container.

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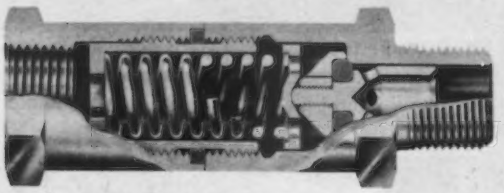

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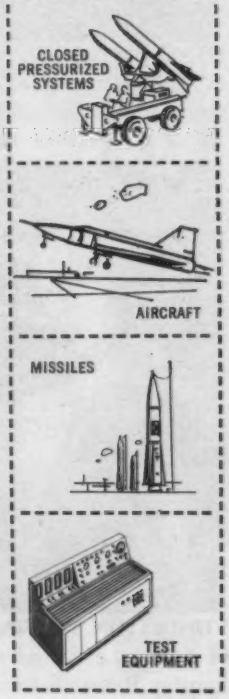


# Industry Notes

## R & D Briefs

**Space power project,** called "Spur," now has Garrett Corp.'s AiResearch Manufacturing Div. as prime. Nuclear-mechanical power system is to be capable of a continuous 300-kw output for about one year.

**Vibration analyzer** just developed by Convair can detect the exact source of vibration in an assembled jet engine.

**Rotary recovery device** is being developed at Kaman Aircraft for the Air Force. Firm will study how helicopter-like rotary wings could slow descent of vehicles to earth.

**Solar power generator** is to be ground tested at Hamilton Standard, Div. of United Aircraft, this Fall. This 100-watt unit will later be designed as a 1500-watt model suitable for satellites in 90-minute orbits.

**Refractory coating** has been sprayed on Rocketdyne's test stands at Neosho for erosion protection.

**Research operations** at Aeronutronic Div., Ford Motor Co., have been reorganized to emphasize "the important and basic scientific disciplines." New research headings include Physical Electronics and Bionics; Mathematics and Computing; Physics; Chemistry and Materials.

**NEW "WASP,"** versatile six-seater, is now in production at Westland Aircraft Ltd. Powered by 970 Blackburn Nimbus free turbine, Wasp has climbed 180 ft/min at 14,000 ft.

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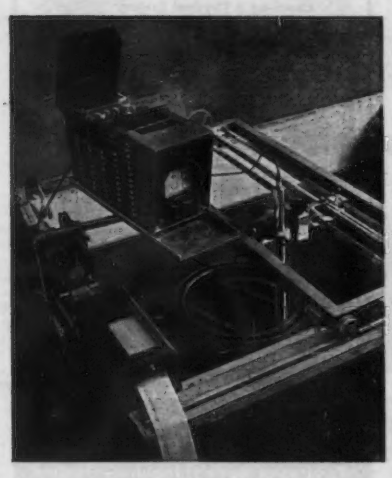
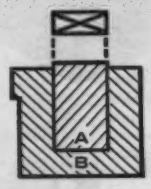
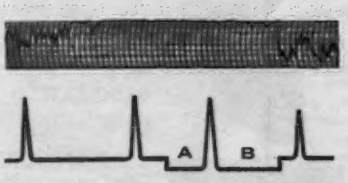


Early warning of internal defects prevents further waste of time and money on materials and parts that would later be rejected or fail in service / Here, for instance, a *Sonoray*® Ultrasonic Flaw Detector with accessory Model B *Sonogate* Flaw Alarm, immersion-scans a vital bi-metallic rotary seal. Every variation in bond between the two dissimilar materials is revealed on the CRT and strip-recorded as the part rotates on the submerged turntable / This is just one of the many DEW* techniques available with Branson Ultrasonic Flaw-Detection and Thickness-Gaging equipment. State your problem in detail when requesting further information.

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## Production Techniques

**Sand blast cleaning** is being utilized during production of sound suppressor - thrust reverser assemblies at Rohr Aircraft. Cleaning is done in a special blast room at Rohr's Chula Vista, Calif. plant. Assemblies are used with Boeing 707's.

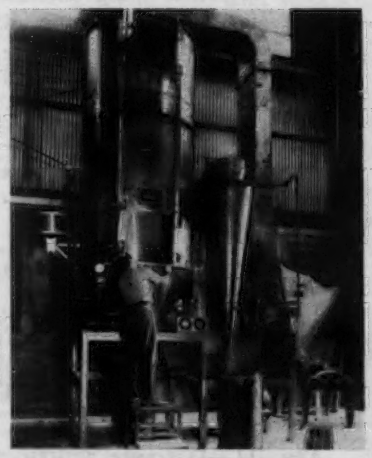
**Mark Century** numerical control system for metalworking machines was recently announced by General Electric. First models are of the numerical contouring type.

## Engineer-Writers

A recent notice issued by Kendall Perkins, vice president of engineering, McDonnell Aircraft, urges company engineers to write for professional journals and outside publications.

Company assistance in the form of "typing, art work and reproduction facilities" are offered. The engineer may "employ a reasonable amount of time within the regular working period" to prepare his papers.

Cost per man-hour for technical writing courses runs an estimated 69.6 cents. Writing classes have enrollment of 174 engineers studying 32 hours per course.



**SPRAY DRYER** speeds up production of ceramics for electronic applications at Diamonite Products Mfg. Co., Shreve, O. System eliminates filter pressing and drying. Manufacturer: Bowen Engineering, North Branch, N. J.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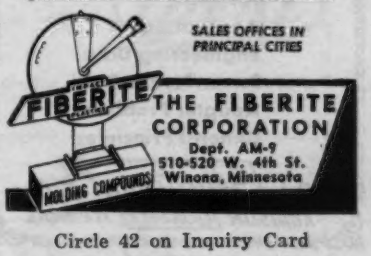


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**General Principles**

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# Industry Notes

## Aerospace Log

**July 20**—Two Polaris missiles make test flights from submerged sub 30 miles off Canaveral. Both go over 1000 miles down Atlantic Missile Range.

**July 25**—Pershing shot about 30 miles from Canaveral. Fired from XM-474 tactical field carrier for first time.

**July 29**—First production model Mercury capsule fired from Canaveral on nose of Atlas. Missile explodes 65 sec after launching.

**July 29**—Advanced model Titan fired, lands in ocean about 90 miles off Canaveral. Cause believed to be a leak in fuel supply line.

**July 31** — Third Polaris fired over 1000 miles from sub.

**Aug. 1**—Navy fires 4th Polaris from submerged sub. Missile veers off course, blown up 47 sec after launch.

**Aug. 2**—Hound Dog hits target 500 miles down Atlantic Missile Range after launching from B-52G.

**Aug. 2.**—Atlas firing checked on pad at Canaveral because of trouble in engine cut-off after ignition. Missile was slated to go 7000 miles.

**Aug. 3**—Polaris fired from underground tube at Canaveral; goes over 1100 miles down Atlantic Missile Range.

**Aug. 4**—X-15 flies 2150 mph —worlds speed record.

**Aug. 9**—Atlas fired 7000 miles from Canaveral.

**Aug. 10** — Discoverer XIII launched.

**Aug. 11**—Discoverer's 300-lb instrument capsule makes successful re-entry. It is recovered north of Hawaiian Islands.

**Aug. 12**—Project Echo's passive communications satellite successfully orbited and reflects signals.


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*Complete facilities for testing products, materials and components*

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*Fully equipped for metal treating and related industrial finishing operations*

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Adjustable stamping depth.
Foil feed adjustable and automatic.
Feed adjustment 1" to 18"
Accommodates wire size AN-26 thru AN-0000, and tubing from 1/16" to 1-1/2" O. D.
Heat range from 100° F. to 600° F. controlled by thermostat and thermometer.
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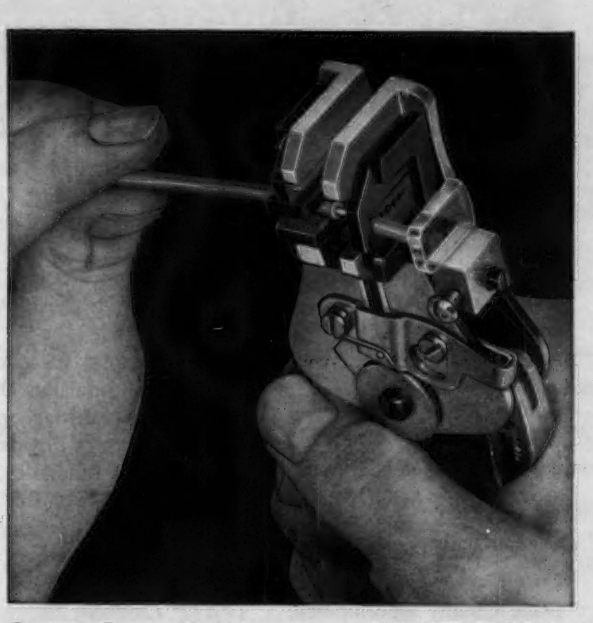

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*To help prevent wire nicking and insulation damage, these new IDEAL "Custom Stripmasters" are precision drilled on watchmaker's equipment.*

With Ideal's new Custom Stripmasters, a light squeeze on the handles strips any wire completely clean and bare up to a full ⅞ inch.

To help prevent nicking and scraping of wires, the Custom Stripmaster's matched sets of blades are precision drilled on watchmaker's equipment to the exact wire sizes. Counterbored blades ride on cut insulation to prevent scratching of stripped wire. Jaws grip wire firmly to prevent insulation damage. 3 models available. Wire sizes from No. 10 to 30.

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High speed dynamic balancing of gyros, rotors etc. to within 10 micro-inches (.000010-inch displacement) is easy with the Olsen-Rava Type S. Part is driven by a belt (as shown) or air at speeds to 36,000 rpm. The amount of unbalance is indicated on a meter, while a strobe light pin-points the "angle" on the rotor.

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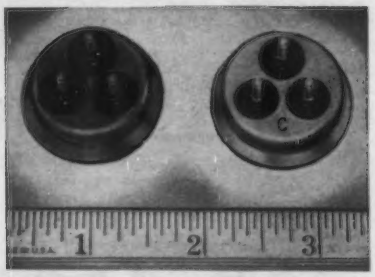

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- Advertisers' Services
- Technical Literature
- New Materials and Components
- New Production Equipment
- New Electronic Products
- and Employment Opportunities

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| 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 |

For the following numbers pertaining to recruitment please use home address.

201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220

**IMPORTANT • MUST INFORMATION**

**YOUR NAME** .....**TITLE** .....

**COMPANY** .....

**PLANT ADDRESS** .....

**CITY** .....**ZONE**.....**STATE**.....

Please check in A & B below which best describes:

**A. Your Job Function**

....1. Management
....2. Design & Engineering
....3. Production
....4. Procurement

**B. Type of Plant or Facility**

....1. Airframe
....2. Propulsion
....3. Electronic Systems & Parts
....4. Mechanical Systems & Parts
....5. Raw & Processed Material
....6. Engineering & Research Services
....7. Military & Government Facilities
....8. Parts & Supplies
....9. Plant or Test Equipment
....0. Other

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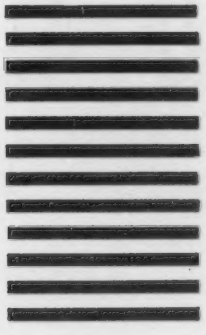

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| 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
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**COMPANY** .....

**PLANT ADDRESS** .....

**CITY** .....**ZONE**.....**STATE**.....

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....5. Raw & Processed Material
....6. Engineering & Research Services
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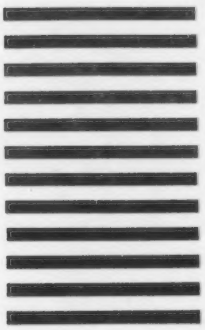

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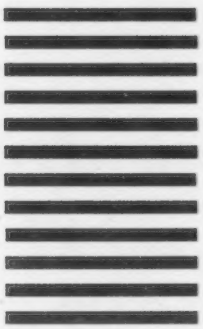

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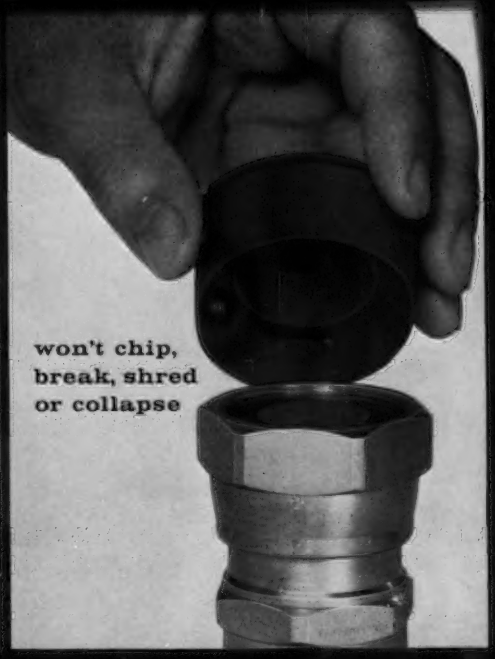

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or collapse

made of tough,
flexible Polyethylene

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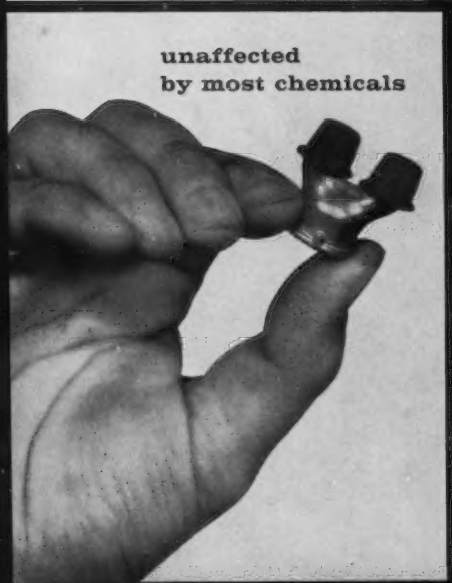
take your pick: over 600 sizes in numerous styles and colors now in stock.



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by most chemicals

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to remove

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Title

Firm

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City Zone State

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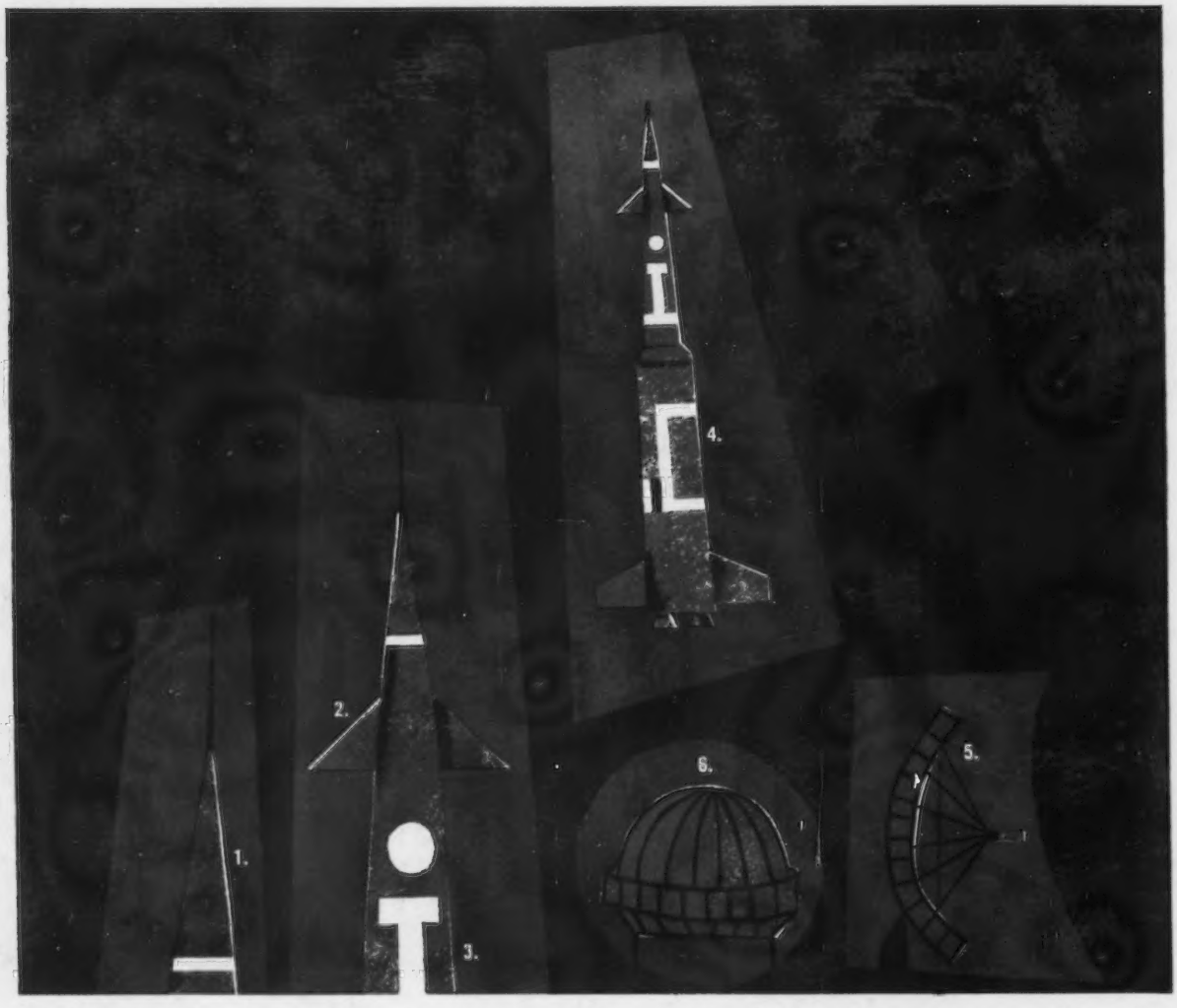


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